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BLOOD PLASMA

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Believing that the readers of this journal would find the story of the processing of blood plasma for the Armed Forces one of considerable interest, a request was made of Mr. Jamieson to supply that story. Mr. Jamieson's department at Eli Lilly and Company, Indianapolis, was principally concerned with biological research before the war. Yet when called on to take over the additional task of processing blood plasma, stupendous though it might prove to be, they readily consented. That their patriotic effort is being recognized is evidenced by this excerpt from an editorial in the Indianapolis News, January 7, 1944:

> "In the midst of charges that some concerns are making an unholy profit from war contracts it is heartening to learn that the Indianapolis laboratories of Eli Lilly and Company have processed 1,000,000 blood donations entirely on a non-profit basis. . . . From beginning to end, it has been and is a magnificent job."

Besides the bleedings received from Indianapolis donors, this company, has handled those from Chicago, St. Louis, Cincinnati, Detroit, Louisville. Atlanta and Columbus. It was perhaps presumptuous to assume that Mr-Jamieson would find time to prepare such an article, but again his willingness to serve was found unwanting, and as a result we have his brief, authoritative, but complete story of the process.

HOWARD F. WRIGHT

A recent issue of the *Journal of the American Medical Association* commenting on the work of the American Red Cross states that during 1943 it secured blood from volunteer donors for processing over four million units of dried human plasma. This is a remarkable performance and one of the outstanding feats of the war.

When the need for human plasma for the treatment of our wounded became apparent, the Red Cross was asked to under-

take the task of securing the necessary blood. A blood donor service was organized and centers were established in certain cities, choice being made on the basis of available population, facilities, and proximity to laboratories which might process the collected blood. At these bleeding centers the donor is enrolled, examinations made, and if accepted approximately one pint of sterile blood is drawn into a sterile bottle. This bottle contains an appropriate amount of sodium citrate solution to prevent clotting of the blood. The bleeding assembly used is supplied to the center by the laboratory to which the bleeding is to be sent for processing. Immediately upon withdrawal of the blood from the donor the bottle of blood is refrigerated. At the end of each day the chilled bloods are packed in special refrigerated containers and shipped to the processing laboratory. All details of shipping are closely supervised as to train schedules for the bloods must reach the laboratory within twenty-four hours and must remain chilled.

Upon receipt at the laboratory the containers are unpacked and the bloods immediately placed in a chillroom. Each blood is tested for acceptability and those found unsatisfactory for any reason are rejected. Rejections usually do not exceed 0.5 percent. The bloods are then centrifuged (in specially equipped machines that hold ten bleedings) to pack the red cells in the bottom of the bottle, leaving the clear, straw-colored plasma as the top layer. The plasma is then syphoned aseptically from some fifty bleedings and pooled in one container. To this pooled plasma 'Merthiolate' (Sodium Ethyl Mercuri Thiosalicylate, Lilly) is added as a preservative.

After passing through a filter the plasma is distributed into 600 cc. bottles, the amount placed in each bottle representing an equivalent of two pints of blood. These bottles are then shell frozen. This is accomplished by placing the bottles on revolving wheels built into a tank containing a liquid mixture which is maintained at a temperature of about $-50°C$. On these wheels the bottles rotate so that about one-fifth of the bottle surface is continually passing through the freezing mixture. The plasma gradually freezes to the sides of the bottle, building up a shell and eventually leaving a hollow core in the center of the bottle. When frozen the bottles are placed at $-20°C$.

The next step is the drying or dehydrating process during which the moisture is removed from the plasma. The bottles of frozen plasma are placed in copper cups attached to a copper

tray and this tray is placed on a shelf in a large vacuum oven. Loading into the ovens must be accomplished and a vacuum drawn before any thawing of the plasma takes place. Warm water then is circulated through the pipes in the shelf on which the tray rests and heat for evaporation is transferred through the shelf to the tray to the cups and then to the bottles of frozen plasma. The vacuum maintained and the amount of heat applied and rate of evaporation are such that the plasma remains frozen until the moisture content is reduced to less than 5 per cent. At this point the temperature of the plasma may be raised without injury to it and the final traces of moisture are removed at 40° to 50°C. The final dried plasma contains less than 1 per cent moisture and weighs about 50 grams. From a 600 cc. bottle of liquid plasma approximately 550 cc. of water are evaporated.

Quick freezing and drying from the frozen state are the most important steps in the process. If carried out properly the plasma retains its original structure and properties and will readily go into solution again. If during the process any part of the plasma thaws out before enough moisture is removed fusion in varying degrees will occur, resulting in an imperfect product which is not easily soluble.

Proper vacuum is obtained by the use of steam jets which in action are similar to the customary laboratory water aspirators except that the propelling power is steam instead of water.

Upon removal from the oven the bottle containing the dried plasma is stoppered under vacuum and then placed in a tin can which also is sealed under vacuum. In the final package a bottle of sterile distilled water, also packed in a tin can but under nitrogen, accompanies the plasma. For use the water is transferred to the plasma bottle, the dried plasma going into complete solution usually within ninety seconds. This reconstituted plasma is then ready for injection.

Throughout the processing numerous tests are run to assure a finished product that is sterile, safe, nonpyrogenic, adequately dried, and readily soluble.

All plasma processed from bloods received from the Red Cross donor centers goes to the armed forces and every drop is accounted for by the laboratory in monthly reports to the Army, Navy, and American Red Cross.

The blood plasma program is a wonderful example of the ability of the American people to do any important job well.

First there is the donor who is willing to give his blood; next the Red Cross blood donor centers which are installed at necessary stations for collection of the blood; then the cooperation of the manufacturing laboratories who have placed their resources, laboratory facilities, and trained personnel on the project to assure a dependable finished product. Excellent cooperation and splendid coordination of the work make possible the prophesy that the goal of around five million units of plasma for 1944 will be adequately met.

ANOTHER APPROXIMATE TRISECTION METHOD*

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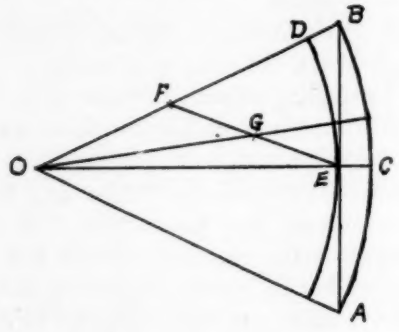
Construction. Let OC be the bisector of angle $AOB=\theta$. Draw the chord AB intersecting OC in E. Construct $OD=OE$. Bisect OD at F and EF at G. Then, $\angle GOF=\alpha$ is approximately $\frac{1}{3}\theta$.

Relationship between α and θ. Since the area of triangle $EOG=\frac{1}{2}OE\cdot OG\cdot\sin(\frac{1}{2}\theta-\alpha)$ and the area of triangle $GOF=\frac{1}{2}GO\cdot OF\sin\alpha$, we have

$$OE\cdot\sin(\tfrac{1}{2}\theta-\alpha)=OF\cdot\sin\alpha.$$

Substituting $OE=2OF$ in (1), we have

$$2\sin(\tfrac{1}{2}\theta-\alpha)=\sin\alpha.$$



solving (2) for α, we obtain

$$\tan\alpha=(\sin\tfrac{1}{2}\theta)/(\tfrac{1}{2}+\cos\tfrac{1}{2}\theta)$$

Errors. For different values of θ, equation (3) yields the following errors

θ	150°	120°	90°	60°	45°	30°	15°	9°
α	51°51′	40°54′	30°22′	20°6′	15°2′37″	10°0′44″	5°0′6″	3°
$\Delta\alpha$	1°51′	54′	22′	6′	2′37″	44″	6″	0

* This trisection formula was derived by Dr. Georges when he was a student in high school.

A DEMONSTRATION OF WAVE ACTION

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The study of waves is an interesting part of both Earth Science and Physics. In the former the student studies the waves of the ocean and of lakes; in the latter he is taught concerning both sound waves and electromagnetic waves which include light waves, radio waves, cosmic rays, etc. Furthermore, since the student has not seen the actual sound or electromagnetic waves, his understanding of these is based on his knowledge of ocean waves. That is, waves formed in water are used as an analogy in the teaching of sound waves and electromagnetic waves. Although electromagnetic waves and sound waves are very different, since the former are transverse or transmitted by vibrations perpendicular to the path of the wave and the latter are longitudinal or transmitted by vibrations along the path of the wave, still the study of each is based upon the student's knowledge of ocean waves. The analogy is used because all of these wave forms are intimately related and what is more important: the student has seen the waves on lakes and oceans so much that he is supposedly quite familiar with what actually takes place there. But unfortunately, this latter supposition is false. The average student does not realize what happens when a wave of water moves.

Suppose the physics teacher takes his class to the shore of a neighboring lake or ocean and asks the individuals to notice the waves. For many, the waves had previously been merely something connected with swimming or surfboard riding. But now, for several of the students, the waves reveal a definite motion. Suppose we see just what that definite motion is, and how the student understands it. First, on looking out to sea the student notices a series of crests and troughs apparently moving toward him. So far, so good. Now, this student is a high school senior, and a member of the physics class, so that we must not expect him to jump at a conclusion after a single glance. But what does further study reveal to him? As he follows the wave in, the troughs and crests continue to approach the shore. Finally, very close to the beach (and this is the spot where the student can see very clearly what is happening) each trough stops and each crest continues for several feet. What is more logical than for that student to assume or even to be sure that a wave is the

forward motion of a wall shaped mass of water skimming (or at least practically skimming) the surface of the lake or ocean? But again, this assumption is false.

The achievements of modern science are based on the principle that students are encouraged to verify facts rather than accept all facts as stated in texts; thus the student must have some method of verifying what we teach him about waves and wave action. We inform the student that in a wave of water the individual drops follow a circular path. Also, we mention that although the wave may travel for a great distance, the individual particles of the transmitting medium move only short distances. But how can the student verify this fact? the wave action chain described later in this article is excellent as a device for demonstrating the actual as well as the apparent motion of the particles comprising the wave. This device is useful in explaining the actual motion of waves of any type.

Suppose the top ring in this "wave action" chain is dropped. The wave or ripple travels the length of the chain and a ring appears at the bottom. In the case of ocean waves the student believed that a wall of water traveled across the water; similarly in this experiment he believes that the top ring has traveled to the bottom. However, in this case the construction of the chain makes a trip of that nature impossible. Moreover, the rings can be marked in such a way that it is easily seen that the motion of each ring is limited by two positions. These two positions correspond to the extreme horizontal displacements of the drops of water in an ocean wave. Similarly, the twisting movement from one position to the other corresponds to the circular motion of the drops of water in the ocean wave. The device may be operated slowly enough so that the oscillating motion of the individual rings is evident. Then the part that each ring plays in the optical illusion (the apparent descent of the top ring to the bottom) is understandable. The individual ring does not and can not travel from top to bottom.

Thus, the student has a comparatively simple example of a series of slight motions by the rings of a chain such that the wave travels the entire length of the chain. The "wave motion" and the "ring motion" can be observed separately. In summary, this "wave action" chain can be used profitably in explaining the real as well as the apparent motion of ocean waves. Either or both of these may then be used as an analogy in explaining electromagnetic waves.

The Construction and Operation of the "Wave Action" Chain

The device described below is not original with the author; similar chains were on sale in the nineteen-twenties as trick rings. However, for several years this chain has been used to demonstrate wave action in the author's classes in Earth Science and Physics.

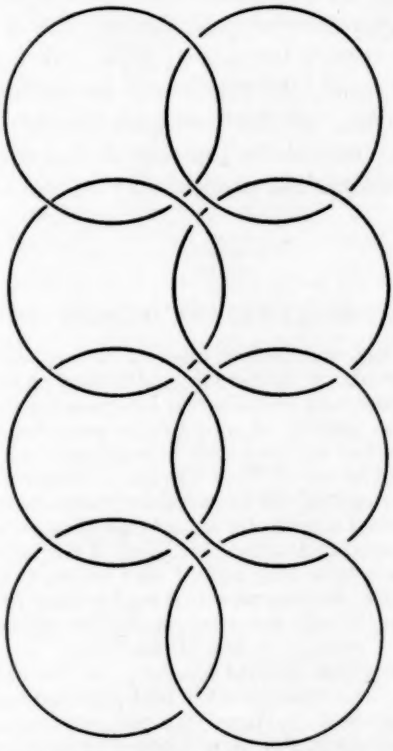

Diagram showing the manner in which the rings are connected in the "wave action" chain.

To make the chain, proceed as follows: secure several key rings or notebook rings. The original chain had twenty rings but this was increased recently to forty rings thus slowing down the action and making the entire demonstration more revealing. These rings are connected as shown in the accompanying diagram. Although only eight complete rings are shown, the final chain may be extended considerably in a vertical direction. Twenty to forty rings are recommended. In connecting the

links to form the chain it will be found that the chain will not lie flat as indicated in the picture. However the actual piecing together will progress rather readily by following the diagram.

To operate the "wave action" chain proceed as follows: grasp the chain by the ring at one end so that the rings form a smooth chain. Notice that this chain is composed of a series of ring pairs with a single ring top and bottom. The top ring passes through each ring in the second layer. However, one of the rings in the second layer does not pass through one of the rings in the third layer but merely touches it. Now, still holding the chain by the top ring, grasp the ring in the second layer at the point at which it touches, but does not pass through, one ring of the third layer. Then release the top ring. A ring will then appear to travel to the bottom. The process may be repeated indefinitely.

THE DUODECIMAL SOCIETY OF AMERICA

Announcement has recently been made of the formation of a new society for mathematical research, the Duodecimal Society of America, established as a voluntary, non-profit organization incorporated in New York state. The purpose of the Society, as stated in its constitution, is "to conduct research and education of the public in mathematical science, with particular relation to the use of Base Twelve in numeration, mathematics, weights and measures, and other branches of pure and applied science."

"We count by tens for no better reason than that we happen to have ten fingers," says F. Emerson Andrews, president of the Society. "Philosophers and mathematicians have long agreed that twelve is a better and more efficient number base than ten; its actual use has been advocated at various times, notably by Herbert Spencer, the British philosopher, and Isaac Pitman, inventor of an early system of shorthand.

"In the past few years, interest has grown in this old idea. A group of experimenters have been trying it out in both practical and theoretical problems—from helping the U. S. Army transport service figure cargo cubages to working with factorials. For some kinds of problems, the savings introduced by dozen-counting are no less than astonishing. The growing number of experimenters and the importance of their findings made a common center for information and further research a necessity, and the Duodecimal Society of America was formed."

According to the literature of the society, counting by dozens can be learned by anyone in the space of about half an hour. Two new numerals are required—*X* to represent ten, and *E* for eleven. Decimals are replaced by duodecimals, so that *.4* means four-twelfths, and is a perfect third—a fraction for which there is no accurate decimal equivalent.

Officers of the Society are George S. Terry of Hingham, Mass., chairman of the board; F. Emerson Andrews of New York City, President; F. Howard Seely of Oakland, Calif., vice-president; and Ralph H. Beard of New York City, secretary and treasurer. The Society is located at 20 Carlton Place, Staten Island 4, New York.

"EQUAL VOLUMES, EQUAL NUMBERS OF PARTICLES"

FRANK B. WADE

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[This article by Mr. Wade has a real message for every science teacher. While directed especially to teachers of chemistry it is applicable to any science subject. Mr. Wade has just entered his 47th year as a teacher and his 42nd at Shortridge high school. He was editor of our high school chemistry department for twenty-four years from January 1914 to December 1938.—G.W.W.]

The late Agnes Hunt of Manchester, N. H., an outstanding scholar and teacher of history, once remarked, "People take the statement 'Columbus discovered America in 1492' without another thought. They never stop to ask why it was Columbus, and why America, and why the year 1492."

Similarly most students of elementary chemistry take the statement that equal volumes of gases contain equal numbers of particles "without another thought." Should we teachers continue to allow our pupils to thus neglect to inquire into the—*why* of this most fundamental physical fact? Hasn't President Robert Maynard Hutchins of The University of Chicago the right idea when he insists (some of his faculty to the contrary notwithstanding) that it is far more important to get students to thinking about a subject than to fill them full of subject matter? Where is that rare high school student who does not think of "equal volumes, equal numbers of particles" whenever he hears the name of Avogadro? Where, too, is the still more rare student who thinks instead of extremely uniform distribution of gas particles under like conditions of temperature and pressure? Should we not try to teach better comprehension of the latter expression of the Avogadro law?

We hope that the brief historical and biographical sketch which follows will lead to that end. We shall attempt to translate directly from the original writings of two great Frenchmen and a great Italian their statements regarding their ideas in this matter, in order that we may think their thoughts over and thereby gain better comprehension of the real meaning of the Avogadro law.

In the year 1809 in the *Memoires de la Société d'Arcueil* Joseph Louis Gay-Lussac (born in 1778) published a memoire, "On the combinations of gaseous substances one with the other." We know the conclusion now as Gay-Lussac's volume

law. We shall translate his "Conclusion," in which he sums up as follows:[1] "I have shown in this memoire that the combinations of gaseous substances the one with the other always take place in the most simple of relations and such that, representing one of the terms by unity, the other is 1 or 2 or at most 3. Such relations by volume are not observed in the least in *solid* or *liquid* substances or when you consider the *weights*, and they are a new proof that it is truly *only in the gaseous state that bodies are placed in the same circumstances* and *that they present regular laws*." (The italics are ours.)

Here was a man who had the key which unlocks the bars which, up to his time, had prevented an understanding of the gas laws. He perceived that back of all the then-known gas laws (he himself probably had priority in discovering the law which we still call Charles' law and which he published in 1802) there lay what he now calls "like circumstances." Oh, that he had had just a bit more insight! It would have heaped the already full measure of his notable achievements.

In 1811, in the *Journal de Physique de Delamétherie* Count Amedeo Avogadro di Quaregna, an Italian scientist, born in Turin in 1776, published an "Essay on a manner of determining the relative masses of elementary molecules, etc." His introductory remarks show that he had been aware of Gay-Lussac's announcement and had been thinking about it. His statement of the Gay-Lussac law, literally translated, is one of the most accurate and compact statements we have seen. He says: "M. Gay-Lussac has shown in an interesting essay that the combinations of gases with each other always take place according to very simple volume relations and that, when the product of the combination is gaseous, its volume is also in very simple relation with that of its components." He then goes on to reason beautifully as follows: "But the relations between the quantities of substances in compounds would appear to depend only on the relative number of molecules which combine with each other and the number of compound molecules which result from it. (Evidently he had John Dalton's ideas in mind.) It is then necessary to admit that there are also very simple relations between the volumes of gaseous substances and the number of molecules

[1] The translations in this article were from copies of the original papers to be found in *Les Classiques de la Science, IV, Molecules, Atoms et Notation Chimiques*, Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris, 1913. Those science teachers who are at home in the French language would do well to secure, as soon as international circumstances will permit, copies of this volume IV, of a series of twelve in which most of the original papers of many great French scientists are to be found.

whether simple or compound which form them." Here he is calling attention to Dalton's small whole numbers of particles and Gay-Lussac's small whole numbers of volumes both of which measure quantities of combining gases. He goes on: "The hypothesis which presents itself first in this respect and which would appear to be the only admissible one is to suppose that the number of integral molecules in all gases whatsoever is always the same in equal volumes or is always proportional to the volumes." We might at least lead our pupils to remember this proportionality rather than the "equal numbers in equal volumes" since they rarely meet with cases of equal volumes.

Avogadro himself doubtless grasped that surprising uniformity of distribution in space which lies back of the proportionality between volumes and numbers of particles, for he goes on to say that "if we were not to assume equal numbers in equal volumes it would then be scarcely possible to conceive that the law which would then preside over the *distances between the particles* could give . . . relations as simple as those which we have just cited, compel us to admit between the volumes and the number of particles."

Now the distances between the particles really determine the distribution in space of the particles and if the distances average out equal then we have uniform distribution and all the gas laws follow as corollaries and can be deduced without any laboratory evidence.

Let us now turn to a letter written by Andre-Marie Ampere (born 1775) to Count Berthollet and published in *Annales de Chemie* in 1814 on "The determination of the proportions in which bodies combine with each other according to the number and the respective disposition of the molecules of which their integral particles are composed." After discussing crystal forms (and coming very near to suggesting unit forms in each crystal lattice) he goes on: "There is another means of knowing these forms; it is to determine, by the relation between the components of a body the number of molecules which are found in each particle of the body. I started for that with the supposition that, in case bodies pass into the gaseous state, their individual particles being separated and scattered, the ones from the others by the expansive force of heat to distances much greater than those where the forces of affinity and of cohesion have any appreciable effect so that the distances depend only on the temperature and the pressure which the gas sustains and

that at equal temperatures the particles of all gases, be they simple or be they compound, *are placed at the same distance the ones from the others.*" (Again the italics are ours.)

Although Avogadro had priority over Ampere in his announcement of the law, we have in Ampere's presentation of it another glimpse of what Gay-Lussac forecast as "like circumstances." Ampere's "snap-shot" of gases showed so uniform a distribution of their particles that the mean distances between particles was the same for all of them.

Should we not, as teachers, try to give comprehension of this great truth to some, at least, of our brighter pupils and try to show them that, had such comprehension been available, all the gas laws might have been deduced without any experimental evidence at all? We may show that even Graham's law of inverse proportionality to the square root of the density follows from Avogadro's law as does Maxwell's law. Show also that, given this view of uniform distribution of molecules, it is easy to see why Boyle's law, for instance, could not be otherwise than it is. [The numbers of "pushers" being equal and each of equal pushing ability (Maxwell's law) of course you would find double the push if they were crowded into half the volume.]

With such comprehension of the real situation it will not be difficult for the student to understand the principal use of the Avogadro law in finding, as Avogadro said himself, "the relative masses of the molecules of all substances which we may have in the gaseous state . . . for the relative masses of the molecules are given immediately by the relations between the densities of the two gases at like temperature and pressure."

To clinch the matter put the student into the laboratory and let him actually determine the molecular weight of, say carbon dioxide, by weighing the gas suspended in a thin walled flask of perhaps 500 cc. capacity and finding how much heavier than air that volume of the gas is. Reduce the volume to standard conditions. Find the weight of that volume of air if one liter weighs 1.29 grams. Add the weight of the air to the gain in weight and you have the weight of the given volume of carbon dioxide. Calculate the weight of 22.4 liters and you have the numerical molecular weight of carbon dioxide.

Some pupil who is faster than the others can be given a sample of a 100 octane gasoline to find its mean molecular weight by using an improvised Victor Meyer type of apparatus. Here you will be on the track of an immensely important war time use of

the Avogadro law and a report on his work by such a student will arouse real interest on the part of the class.

You say, "All this will take a lot of time." Perhaps, but isn't it worth it? Simply cut out enough subject matter to allow time for a few worth-while studies like this.

CHARLES ARTHUR STONE

Charles A. Stone, whose name has appeared as one of the three mathematical editors of *School Science and Mathematics* since March 1930, died suddenly August 14, 1944 of heart failure due apparently to overwork.

Professor Stone was born in Chicago, August 17, 1893. He was graduated from the University of Illinois in 1917 with the degree of B.S. with ceramic engineering as his major interest. During the year following his graduation he was employed as a ceramic engineer by the Basic Products Company of Kenova, West Virginia. After one year of engineering he was made principal of the Kenova High School. During the years 1919 to 1921 he was the assistant principal of the high school at Des Plaines, Illinois. In 1922 he became an instructor in the laboratory schools of the University of Chicago and continued this connection until 1935. From 1924 to the time of his death he was a professor of education at De Paul University. Thus, during a period of eleven years, he held positions simultaneously in both institutions.

He was awarded the degree of A.M. at the University of Chicago in 1925 and the title of LL.D. by Niagara College in 1930.

In addition to his duties as a teacher he was one of the mathematical editors of SCHOOL SCIENCE AND MATHEMATICS and also the mathematical editor of the F. W. Davis Publishing Company. During the years 1932 and 1933 he was respectively Vice-president and President of the Central Association of Science and Mathematics Teachers. In this association his counsel was valuable and his judgment good with respect to both academic and administrative problems. As an author and writer Stone was well known. In addition to the many articles on the teaching of mathematics in this and other educational journals, he was the co-author of the following books: *Trigonometry*, Breslich

and Stone, *The Slide Rule* Brelsich and Stone, and *The Teaching Unit*, Waples and Stone.

Stone was a sympathetic, understanding, and accommodating teacher. He gave his time and energy unstintingly to his students. His background in mathematics, engineering, and education qualified him especially to teach the pedagogy of mathematics. He was a progressive teacher but one who did not accept a new idea until he had given it careful consideration. Hundreds of teachers who have worked in his classes will miss his counsel and his inspiring lectures.

J. M. KINNEY
GLEN W. WARNER
J. S. GEORGES

THE CUMULATIVE INDEX

To the many thousands who have found *The Chemical Formulary* so helpful, a new, useful tool has now been made available in the form of *The Cumulative Index*.

This comprehensive index covers all the formulae included in the complete six volumes of *The Chemical Formulary*. With this handy book there is no need to search through all the six volumes to find what you want when you need it. *The Cumulative Index* indicates at a glance the volume and page number for each item in all six volumes. The material has been arranged in strict alphabetical order to facilitate quick reference. Numerous cross references will instantly lead the user to all possible subjects relating to formulae or processes which are of interest. It may be obtained direct from the publisher, Chemical Publishing Co., Inc., 26 Court St., Brooklyn 2, N. Y., or from your book dealer. It is $4.00 a copy.

NOTED CHEMISTS TO TALK AT WAR-TIME SHOW

Contributions of industrial chemical engineering to the petroleum, synthetic rubber and other industries will be revealed by noted authorities at the National Industrial Chemical Conference to be held in conjunction with the third biennial National Chemical Exposition at the Coliseum in Chicago, Nov. 15 to 19.

Sponsored by the Chicago Section of the American Chemical Society, the show and conference will be the most important of its kind ever held because of its war-time significance and also because of the vital part the industry is taking in helping to speed Allied victory.

Invitations have been extended to leading authorities in many phases of the chemical industry to present their views at the conference and to lead the discussions.

In a symposium on "The Future of Metals in Post War," Dr. L.B. Grant of the Dow Chemical Company, Midland, Michigan, will talk on magnesium; Dr. J. V. Faragher of the Aluminum Company of America, Pittsburg, Pa., will discuss aluminum, and Mr. John Mitchell, metallurgical engineer of the Carnegie-Illinois Steel Company, Pittsburgh, Pa., will speak on new steel alloys.

THE FIBONACCI NUMBERS

ADRIAN STRUYK
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The Fibonacci numbers constitute an interesting mathematical byway. An article[1] in a recent issue of this journal mentioned their occurrence in nature and in art. Since very elementary means suffice to investigate many of their properties these numbers furnish ready material for club topics and classroom supplements. The present article deals with some of this material.

We may begin by writing the first dozen of Fibonacci's numbers:

$$1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, \cdots. \tag{1}$$

Excepting the first two, each number in this sequence is the sum of the two which precede it. Hence, using f_n to denote the nth term, we may express the law of succession as

$$f_n = f_{n-1} + f_{n-2}. \tag{2}$$

This law and the specification that

$$f_1 = 1, f_2 = 1 \tag{3}$$

serve to define the sequence (1).

Fibonacci's numbers are related to numbers whose powers obey the same law of succession. If x denote such a number then

$$x^n = x^{n-1} + x^{n-2}. \tag{4}$$

Since we contemplate only non-zero values of x we may divide (4) by x^{n-2}, thus obtaining

$$a)\ x^2 = x + 1, \text{ or } b)\ x^2 - x - 1 = 0. \tag{5}$$

The roots of (5) are found to be

$$a)\ g = \tfrac{1}{2}(1+\sqrt{5}), \quad b)\ h = \tfrac{1}{2}(1-\sqrt{5}), \tag{6}$$

having the relations

$$a)\ g+h = 1,\ b)\ g-h = \sqrt{5},\ c)\ gh = -1. \tag{7}$$

In g we recognize the number which expresses the ratio of the larger part to the smaller of a line-segment divided in extreme

[1] Winsey and Sands, Contributions of Mathematics in the Development of Art, School Science and Mathematics, XLII, p. 851, December 1942.

and mean ratio (the golden section). We recall that, in this partition, the whole segment is g times the larger part while the latter is g times the smaller.

There have now come to our attention three sequences whose nth term t_n is given by

$$t_n = t_{n-1} + t_{n-2}. \tag{8}$$

These are the Fibonacci sequence (1),

$$1, 1, \cdots, f_n, \cdots,$$

and the geometric sequences

$$g, g^2, \cdots, g^n, \cdots, \tag{9}$$

$$h, h^2, \cdots, h^n, \cdots. \tag{10}$$

Concerning the third one we may note that the terms are alternately negative and positive because the number h is negative, and that

$$h^n \to 0 \text{ as } n \to \infty \tag{11}$$

because the absolute value of h is less than 1. Concerning all three sequences there are certain consequences of the succession law (8) which we proceed now to derive.

Since g and h are the roots of (5)

$$g^2 = g + 1 \quad \text{and} \quad h^2 = h + 1.$$

Because of (7a), therefore,

$$h = 1 - g, \quad \text{and} \quad h^2 = 2 - g.$$

Hence we compile the following table, in which each line after the second is, in accordance with (8), the sum of the two lines above it.

$g = 1g,$	$h = 1h,$	$h = 1 - 1g,$
$g^2 = 1g + 1,$	$h^2 = 1h + 1,$	$h^2 = 2 - 1g,$
$g^3 = 2g + 1,$	$h^3 = 2h + 1,$	$h^3 = 3 - 2g,$
$g^4 = 3g + 2,$	$h^4 = 3h + 2,$	$h^4 = 5 - 3g,$
$g^5 = 5g + 3,$	$h^5 = 5h + 3,$	$h^5 = 8 - 5g,$ etc.

It is apparent that, in general,

$$g^n = f_n g + f_{n-1}, \qquad h^n = f_n h + f_{n-1}, \tag{12}$$

$$h^n = f_{n+1} - f_n g. \tag{13}$$

The numerical values of g and h, as given in (6), may be treated similarly.

$$g=\tfrac{1}{2}(0+1\sqrt{5}+1), \qquad h=\tfrac{1}{2}(0-1\sqrt{5}+1),$$
$$g^2=\tfrac{1}{2}(1+1\sqrt{5}+2), \qquad h^2=\tfrac{1}{2}(1-1\sqrt{5}+2),$$
$$g^3=\tfrac{1}{2}(1+2\sqrt{5}+3), \qquad h^3=\tfrac{1}{2}(1-2\sqrt{5}+3),$$
$$g^4=\tfrac{1}{2}(2+3\sqrt{5}+5), \qquad h^4=\tfrac{1}{2}(2-3\sqrt{5}+5),$$
$$g^5=\tfrac{1}{2}(3+5\sqrt{5}+8), \qquad h^5=\tfrac{1}{2}(3-5\sqrt{5}+8), \text{ etc.}$$

The general result indicated is

$$g^n=\tfrac{1}{2}(f_{n-1}+f_n\sqrt{5}+f_{n+1}), \qquad h^n=\tfrac{1}{2}(f_{n-1}-f_n\sqrt{5}+f_{n+1}). \quad (14)$$

As a third consequence of (8) consider the numbers

$$g-h,\ g^2-h^2,\ \cdots,\ g^n-h^n,\ \cdots.$$

Since the terms of the sequences (9) and (10) obey (8) it follows that the above sequence of differences also obeys that law. Let each term be divided by $g-h$. Then the sequence of quotients

$$1,\ g+h,\ \cdots,\ \frac{g^n-h^n}{g-h},\ \cdots,$$

also obeys (8). Taking account of (7a), it follows that the above sequence is identical with

$$1,\ 1,\ \cdots,\ f_n,\ \cdots,$$

the Fibonacci sequence. Hence

$$f_n=\frac{g^n-h^n}{g-h}. \quad (15)$$

Substitution of the numerical values given in (6) and in (7b) results in the equation[2]

$$f_n=\frac{1}{\sqrt{5}}\left[\left(\frac{1+\sqrt{5}}{2}\right)^n-\left(\frac{1-\sqrt{5}}{2}\right)^n\right], \quad (16)$$

which expresses f_n as a function of its position, n, in the sequence (1).

Equations (12) to (15) lead to some simple properties of the Fibonacci numbers.

[2] In Steinhaus: Mathematical Snapshots, G. E. Stechert & Co., N.Y., p. 28, there appears a formula which yields, not every term, but the 3rd, 5th, 7th, etc. For a correct statement see Ball, Mathematical Recreations and Essays, Macmillan, London, 11th edition (Coxeter revision) p. 57.

From equations (12), by multiplying, and using (7*a*, *c*),

$$f_{n-1}^2+f_{n-1}f_n-f_n^2=(-1)^n, \tag{17}$$

which relates any two consecutive terms of (1). Write (17) in the form

$$f_{n-1}(f_{n-1}+f_n)-f_n^2=(-1)^n$$

and apply the succession law. Then

$$f_{n-1}f_{n+1}=f_n^2+(-1)^n. \tag{18}$$

This equation has an application in the construction of fallacies of a common type.[3]

Another form of (13) is

$$\frac{f_{n+1}}{f_n}=g+\frac{h^n}{f_n}.$$

This equation shows that, because of the nature of h as pointed out in (10) to (11), the ratio

$$r_n=\frac{f_{n+1}}{f_n}\to g \text{ as } n\to\infty. \tag{19}$$

Forming in succession $r_1, r_2, r_3, \cdots$ we obtain the convergent sequence

$$\frac{1}{1}, \frac{2}{1}, \frac{3}{2}, \frac{5}{3}, \frac{8}{5}, \frac{13}{8}, \frac{21}{13}, \cdots,$$

the limit of which is $\frac{1}{2}(1+\sqrt{5})$.

A related sequence is easily derived. From (6*a*)

$$\sqrt{5}=2g-1.$$

This relation suggests the ratio R_n, defined by

$$R_n=2r_n-1,$$

and having the property

$$R_n\to\sqrt{5} \text{ as } r_n\to g.$$

From the succession law and the definition of r_n it follows that

$$R_n=\frac{f_{n-1}+f_{n+1}}{f_n}.$$

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[3] See pp. 85 and 86 of the previously mentioned work of Ball.

Consecutive values of R_n lead to the convergent sequence

$$\frac{1}{1}, \frac{3}{1}, \frac{4}{2}, \frac{7}{3}, \frac{11}{5}, \frac{18}{8}, \frac{29}{13}, \cdots,$$

with limit $\sqrt{5}$. The sequence is easily continued because the numerators obey (8).

The product of equations (14) is

$$(gh)^n = \tfrac{1}{4}[(f_{n-1}+f_{n+1})^2 - 5f_n^2].$$

From this and (7*c*),

$$5f_n^2 + 4(-1)^n = (f_{n-1}+f_{n+1})^2. \tag{20}$$

It follows that $\sqrt{5f_n^2-4}$ or $\sqrt{5f_n^2+4}$ is an integer according as n is odd or even.[4]

Using (7c) with (15) we can show that the sum of the squares of two consecutive Fibonacci numbers is a Fibonacci number. In fact

$$f_n^2 + f_{n+1}^2 = f_{2n+1}. \tag{21}$$

Either side of (21) is easily obtained from the expression

$$(g^{2n+2} + g^{2n} + h^{2n} + h^{2n+2})/(g-h)^2.$$

We may also consider briefly sequences which obey (8) and whose initial term t_1 is any number, second term t_2 any number except gt_1 or ht_1. Then the sequence is not geometric. The nth term of such a sequence can be expressed in the form

$$t_n = ag^n + bh^n. \tag{22}$$

The coefficients a and b are the numbers which satisfy the system

$$a+b = t_2 - t_1, \qquad ga+hb = t_1. \tag{23}$$

Beginning with (23) and operating in accordance with (8) we obtain in succession

$$ag^2 + bh^2 = t_2, \qquad ag^3 + bh^3 = t_3, \qquad ag^4 + bh^4 = t_4, \text{ etc.},$$

with the general result as in (22).

The values of a and b as found from (23) are

$$a = (t_2 - ht_1)(5-\sqrt{5})/10, \qquad b = (t_2 - gt_1)(5+\sqrt{5})/10. \tag{24}$$

[4] For some very elementary recreational material based on this property see the article Diophantine Recreations, School Science and Mathematics, XXXV, p. 269, March 1935.

It is apparent that a is positive or negative according as t_2 is greater or less than ht_1. That later terms of the sequence all take the sign of a is clear from (22) after taking account of the nature of h.

In the second member of (22) add and subtract the quantity bgh^{n-1}. Then

$$t_n = g(ag^{n-1}+bh^{n-1}) - bh^{n-1}(g-h) = gt_{n-1} - bh^{n-1}\sqrt{5}.$$

From this and (11),

$$\frac{t_n}{t_{n-1}} \longrightarrow g \text{ as } n \longrightarrow \infty. \tag{25}$$

We conclude this sketch with a few simple geometrical interpretations and applications.

From an origin O draw a ray l_1. On l_1 plot points P_1, P_2, P_3, $\cdots, P_n, \cdots$, so that $OP_1=1$, $OP_2=1$, $(P_1 \equiv P_2)$, $OP_3=2, \cdots$, $OP_n=f_n$. These points then represent the Fibonacci numbers. At the same time the spaces $P_2P_3=1$, $P_3P_4=1, \cdots, P_{n-1}P_n=f_{n-2}$ represent the Fibronacci series

$$1+1+2+3+5+ \cdots.$$

According to (19), as more points are plotted along the ray, the more nearly does P_n divide $P_{n-1}P_{n+1}$ in extreme and mean ratio.

On a second ray l_2 with origin O′ take $O'Q_0=1$ and then construct $O'Q_1=g$. Point Q_2 representing g^2 can then be plotted by making $Q_1Q_2=1$. Laying off additional spaces by making each the sum of the two which precede it we locate points representing the powers of g, since $O'Q_n=g^n$. The spaces beginning with Q_1Q_2 represent the series

$$1+g+g^2+g^3+g^4+ \cdots$$

since $Q_{n-1}Q_n=g^{n-2}$.

If the rays l_1 and l_2 be made to coincide then Q_{n-2} will divide $P_{n-1}P_n$ in extreme and mean ratio. This follows from the first of equations (12), which may be written

$$g^{n-1}+g^{n-2}=f_ng+f_{n-1}.$$

Hence

$$g^{n-2}-f_{n-1}=g(f_n-g^{n-2}),$$

so that

$$P_{n-1}Q_{n-2}=gQ_{n-2}P_n.$$

Any two spaces AB_1, B_1B_2 on a line may serve to initiate a series of segments that obey (8). Then, according to (25), B_{n-1} tends to divide $B_{n-2}B_n$ in extreme and mean ratio.

The property expressed in (19) finds application in approximating such figures as the golden rectangle, regular pentagon and regular decagon, whose exact construction depends upon extreme and mean ratio. These approximations involve the selection of suitable lengths from ordinary or diagonal scales. Good figures can be drawn quickly and easily. For example, a rectangle 34 units by 55 units is about .013 of a unit too short to be "golden," while a 55 by 89 rectangle is about .008 of a unit too long.

Consider a pentagon $ABCDE$ with sides f_n units and diagonals BD and CE f_{n+1} units. It is regular if $BE=f_{n+1}$ units. Let w denote the length of BE. Applying Ptolemy's theorem to the cyclic quadrilateral $BCDE$

$$f_n^2+wf_n=f_{n+1}^2.$$

From this and (17)

$$w=f_{n+1}+\frac{(-1)^n}{f_n}.$$

Hence BE is 1/34 of a unit shorter than BD if $n=9$, 1/55 longer if $n=10$.

To approximate a regular decagon draw a circle with radius f_{n+1} units. Then lay off two successive chords f_n units long both ways from both ends of a diameter. This distributes the error equally between the two sides parallel to the chosen diameter.

LYE SPEEDS POTATO PEELING

Potatoes can be peeled at the rate of more than 18,000 pounds per hour when lye is used to do the job, A. H. Copeland, Jr., R. M. Chatters and R. D. Kerwin, of the research laboratories of the Diamond Alkali Company at Painesville, Ohio, reported.

The lye peeling method is now being widely used for other vegetables and fruit for the armed services. Besides the saving in labor, new medicinals, plastic ingredients and valuable oils have been discovered in peels and seeds hitherto wasted.

INTEGRATED BOTANY AND ENGLISH

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A combined Botany-English class was initiated and carried through the school year, 1943–44, at Arsenal Technical Schools. This was the first organized integration of its kind at the above-named school, although similar plans have been developed in other cities and are now in progress. These include integrated classes in Economics and Chemistry, American History and Chemistry, Biology and English, Social Science and English, and Social Science, Science, and English. In one city, Social Science, Science, Mathematics, English, Art, and Music have cooperated as departments in developing a course of study for ninth year students.

STRUCTURE OF THE COURSE

The experimental class at Arsenal Technical was planned for tenth year students, since the majority of students selecting Botany are sophomores. These students studied English III, a composition course, the first semester, and English IV, a literature course, the second semester. Except for two students whose programs could not be satisfactorily arranged for the second semester, the class remained intact. Two new persons were added to replace the withdrawals. Since all science at Arsenal Technical meets for a double period each day, the combined Botany-English course was necessarily a three-period class each day. English was usually taught first and Botany second, but the arrangement was very flexible. A few times, English occupied two periods when a panel or round table discussion was in progress. There were also several occasions when science extended through three periods, because a speaker followed by class discussion or experimentation was on the program for the day.

Two teachers, one Botany and one English, were available each day for two of the three periods. Usually one took charge and the other gave supplementary aid when requested. Occasionally both took active part when correlating certain topics of prime importance, or when establishing a firm scientific background for some form of written or oral report. Both teachers were allotted the period preceding their class as a planning

period. This opportunity to talk over their work and to plan ahead is as necessary to the success of such a course as are enthusiasm and initiative in the teachers concerned.

During the second semester, the class met the seventh, eighth, and ninth periods. This proved ideal for trips and outdoor activities, for with such an arrangement it was possible to leave the school grounds around one-thirty o'clock, spend several hours at the place of interest, and be dismissed to go home at the usual school dismissal hour of three forty-five o'clock.

Content of Course

The basic material of the course was botanical and biological. From this material the English class derived its topic sentences, its inspirations for paragraphs and compositions, its suggestions for letters, interviews, roundtable and panel discussions, and its class reports. Radio skits and playlets were developed around the study of foods, diets, and health. Articles, pamphlets, and books of scientific developments, science history, and biographies of scientists furnished material for class and outside reading. Films, outside speakers, and trips were always an excellent source of ideas and topics for oral and written reports. Science words supplemented the regular English spelling lists for English III and IV. During the second semester more poetry and literature were read. This, as will be shown, correlated remarkably well with the science study. At the close of each unit of study, a paper was written by each student, in some instances to summarize the material studied, at other times to make application of information learned to familiar situations or to the individual himself. These papers were graded by the Botany teacher for accurate scientific information, and by the English teacher for correct spelling, and sentence and paragraph construction.

The science units may be briefly listed as follows: Science versus Superstition, Trees in Indiana, Food Getting, Food Uses, Reproduction, Heredity and Change, Health and Disease, Community Development, Gardening, Economic Plants and Animals, Conservation of Community Resources, Hobbies and Vocations.

While space does not permit the discussion of science-English cooperation in every unit, it will be of interest to relate several instances of such integration. During the study of "Trees in Indiana," the science class made trips to the School Nature Pre-

serve and on the campus to use simple tree keys and to collect leaves, bark and fruits. Tree distribution, environmental effects, and conservation aspects were especially stressed. The Indianapolis Weather Bureau and Indiana State Conservation Department contributed helpful statistical materials and pamphlets. Forest uses and wood products stimulated an unusual amount of interest. The English class correlated its study with that of science by writing letters for pamphlets and exhibits of wood products by reporting on visits to department stores, wood-working courses and wood-carving shops, and by reading pamphlets on *American Forests* and *Conservation in Indiana*. Science films such as *Conservation of Natural Resources, Trees for Tomorrow*, and *Trees to Tame the Wind* were viewed and described in paragraphs, or used to furnish ideas for topic sentences. Library work on science assignments was begun as a group project.

While the science class explored the complexities of soil, performed photosynthesis experiments, studied plant structures microscopically and made food tests in the study of "Food Getting" and "Food Uses," the English class read *Hunger Fighters, Boy Life on the Prairie*, and several nutrition booklets. Charts on weekly diets, balanced daily menus and the meaning of vitamins, minerals, and calories in foods were accompanied by a visit to the Home Economics Department to see a display of wartime balanced meals and food stretchers and substitutes. A few days later, a Home Economics teacher talked to the science-English class on *Nutrition and Health*. A trip to the Indianapolis City Market where kinds of foods sold, sources of each and prices asked formed an interesting project for the class. One committee made a census of vegetables and fruits most often requested by Indianapolis families, another of meats, fish, and cheese.

Two developments in the English class during the study of heredity brought forth enthusiastic participation from class members. One of these was a study of juvenile delinquency followed by a roundtable discussion, and the other was a consideration of the negro-white problem with a panel of eight presenting the composite opinions and conclusions of the class. Other races were not discussed to any extent, since Indianapolis is made up chiefly of white and negro population. Biographies of noted negroes were reviewed and selections from prose and poetry written by negro authors were read. The school choir sang some negro songs and hymns for the class.

The study of health and disease drew upon the Indiana University Medical School and the Indiana State Board of Health for materials and speakers. Health services and statistics for Indiana and Indianapolis were reviewed and discussed. Paul de Kruif's *Microbe Hunters* was read by the English class. Diseases and their treatment as well as biographies of medical scientists were reported. The health problems of teen-age boys and girls stimulated an enthusiastic roundtable discussion. Films supplemented much of this study. A trip to the Indiana State Board of Health to learn of the work of its many departments concluded the unit.

One of the most interesting units of the entire course proved to be "Community Development." While the science class studied plant and animal distribution, development of plant and animal communities and interrelationships of plants and animals within communities, the English class undertook a study of human communities. They first read novels and sketches of American life, both pioneer and modern. Selections were made by each student and the book setting and story reported in class. During this time, *Americans All*, a collection of stories on various phases of American life, was read as a class project. Indiana novels followed including several with settings in Indianapolis. The science teacher correlated the study of plant-animal and human communities for the students and in so doing gave the geographical, natural, and agricultural setting of Indiana. Maps and charts were profusely used. A trip to the Children's Museum gave portrayal to many aspects of American and Hoosier life.

The work on gardening was actually productive since the class planned, made, and cultivated its own vegetable garden on the campus. A five-acre Nature Preserve, owned by the school, furnished a variety of natural habitats for plants and animals, including an abundance of wild flowers. The English class devoted its study to poetry, particularly nature poetry, during the outdoor work. A class poem about "Spring" was written and sent away for publication.

"Economic Plants and Animals" provided an excellent basis for study of other parts of the world. While this was done specifically for sources and distribution of foods, medicines, oils, fibers, rubber, and many other products in the science class, the English class read pamphlets and stories on Latin-American countries, Australia, New Zealand, Hawaii, and the South Pa-

cific Islands. A teacher of the Spanish department gave the students a most enjoyable presentation of customs, language, and dress in South America. A South American "fiesta" with colorful costumes, music, and products furnished a delightful conclusion for this unit.

"Conservation of Natural Resources" proved a worthwhile medium for travel sketches and wildlife stories in the English class. Water, soil, coal, petroleum, and gas were among the resources considered. National and state parks and forests were located and discussed as to purpose and scenic beauty. Films and pamphlets published by government conservation agencies added to this study. Wildlife preserves, bird sanctuaries, and fish hatcheries were described by class members who had visited Indiana localities housing these. A representative of the Indiana State Department of Conservation talked to the class about wildlife breeding and preservation. A trip was made to Holliday Park, the finest forest and wildlife preserve in Indianapolis.

On the last day of the semester, a hobby-lobby was held with exhibits and talks on varied recreational pursuits. A number of displays on insects, bird paintings, wild flower sketches, and tree collections indicated interests of long standing in the out-of-doors. Several who had had no particular hobby expressed a desire to begin such collections during the summer.

Community Study

As already mentioned, the local and state community contributed to the combined Botany-English course in numerous ways. Visits were made to city forest and wildlife preserves, to the large central city market, to greenhouses, to the Indiana State Board of Health, to the Children's Museum, to the Indiana State Library, and to the Indiana State Department of Conservation. Statistical material, pamphlets, and maps were secured from the Indianapolis Weather Bureau, the Indianapolis Public Welfare Agencies, and several state departments. Numerous books were loaned by the Indianapolis Public Library on Indiana history, travel, and stories of American life. Speakers from the Farm Bureau, the Indiana State Department of Conservation, the Indiana State Board of Health, and several departments within the school added much to the class study. Community geography and setting, water and fuel resources, housing and health services, food and other agricultural industries, recreational and cultural facilities were among the com-

munity areas included in the combined study. These served to stimulate new interest and appreciation of city resources and services.

Evaluation

Evaluation in this course has been primarily informal. Some written tests on information have been given by both teachers, but reports, discussions, letters, diaries, summaries, and playlets have been considered far more valuable in evaluating changes in student abilities, interests, and appreciations. Such methods of evaluation have also proved useful in determining the strong and weak points of the course. Certain units had more appeal for students than others. This might be the result of more outdoor work in some, and an extraordinary amount of laboratory experimentation in others. Sometimes one unit had more practical application than another, or better explanation of teen-age problems. The varied approach to any problem secured more and lasting interest. Informal conversations and interviews with class members over the period of a year brought forth many reactions never secured in the class. Perhaps the best vehicle for learning student opinions of everyday problems and student estimates of unit materials was the round table and panel discussions. Student chairmen always organized and directed such discussions. Spontaneity of expression and the wholesome unbiased opinions of youth were a delight and inspiration.

Student evaluation of the combined course can best be expressed in student words:

"English is made easier and more interesting."

"We are given something new to talk about each day in class."

"Class time passes so rapidly!"

"We learn to know one another so much better that we are not afraid to talk before the class."

"Science furnishes us definite subjects for compositions and paragraphs."

"The combined course has helped me to like science better. I plan next to take Chemistry."

The teachers of the course agree that the integration has been successful, because

1. Students elected to remain in the combined class through the entire year.

2. Less absence was recorded in the class than in other Botany and English classes of comparable size and grade.
3. Eight students, or one-third of the class, chose to continue with science.
4. Except for three final grades, the English and Botany grades of the students coincided exactly. These grades were made out without conference on the part of the two teachers.
5. New devices and new materials have been available which in a class of Botany or English would not have been accessible to the teacher.

CAN YOUR STUDENTS *TALK* MATHEMATICS?

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There is a tendency among mathematics students to call equations and parabolas and series and determinants simply "things." This is an ominous tendency, and it is apparent even on the college level. At best it represents slip-shod expression of concepts better understood; at worst it represents a gross misunderstanding of concepts fundamental to the science. The latter possibility seems more likely: a man is no more a mathematician if he cannot *talk* mathematics than he is a chemist if he cannot *talk* chemistry or a musician if he cannot *talk* music.

There is some consolation for defenders of the science in the fact that the same freshman who dubs the quadratic formula a "job"—and dares us to misinterpret his statement—is the first to interfere if we do not draw very proper distinctions between the P-40 and the P-47 and the P-39. Perhaps the faculty for exact thinking is not extinct but is just dwarfed or directed into other channels!

More than ever before, such an important aspect of training in mathematics as the teaching of vocabulary and concepts demands conscientious effort on the part of the instructor. Merely allowing a beginning student the privilege of watching the trained mathematician at work is not enough: the art student does not become a painter just by observing the mature artist at work; the young musician does not acquire skill in composition just by listening to Beethoven for hours-on-end. Audience with a master craftsman is a necessary, but not sufficient, condition

for training the apprentice to handle his tools properly. The student must be summoned to active participation in the science!

The methods for encouraging a student to use a mature mathematical vocabulary correctly and with confidence are many.

The written assignment, prepared outside class, has merit (Who would deny its indispensability in over-all training in mathematics?), but it is not evidence of a workable vocabulary, capable of spontaneous use without reference to a glossary or textbook.

Question-answer discussion between instructor and student is invaluable; it is vastly more effective in high school and undergraduate college courses than is a continuous monologue from the rostrum. The student may *agree* with every statement his instructor makes, just as he invariably *agrees* with every exercise solution produced by his instructor; but it is vastly more difficult for him to *initiate* properly phrased statements of his own ideas, just as it is more difficult for him to *initiate* his own solutions to exercises. In science, as in art, it is easier to *concede* the correctness of a masterpiece than it is to *create* a masterpiece.

Questions such as the following, for a class in college algebra, would be both lively and thought-provoking; and they would serve as an accurate measure for the students' understanding of fundamental concepts:

1. What is the value of 10 raised to the power $\log_{10} x$?
2. Evaluate $2 \cdot 8 \cdot 4^3$ by logarithms, using 4 as base.
3. In $\log_a N = L$, what is the possible range of values for a?
4. Distinguish between $\log(a/b)$, and $(\log a)/b$, and $\log a/\log b$.
5. In $y = 2x + zx$ is "the value of y determined when a value of x is given?" Is y, then, a function of x?
6. Is a man's income tax a function of the number of his dependents? Of the number of his friends?
7. Name all mathematical terms attaching to the expression

$$[i\sqrt{3}\,(x^2+2ax+\pi) \div \tfrac{2}{5}] \times \tfrac{5}{2}.$$

(Answer: exponent, base of power, power, trinomial, sum, product, quotient, rational, irrational, transcendental number, real, imaginary, variable, constant, function, coefficient, term, factor, degree, radical, etc.)

Questions such as "If $A=R[(1+i)^n-1]\div i$, find A when $R=\$30.00$, $i=.04$ and $n=10$," though meritorious for other purposes, have no place here; a seventh grader can evaluate *lwh*, given $l=2$, $w=3$, $h=4$.

Classroom discussion is further enhanced if the instructor uses as much technical language as he can, while still making himself understandable to the class. Nothing is as effective in fostering the tendency in students to use vague, general terms for specific, well-defined concepts as is the same practice on the part of the instructor (sore as is the temptation upon him!). And it is for the benefit of the class that comments and questions which come from them should be interpreted at face value, with no missing meanings or phrases taken for granted. (Of course the practice, if carried too far, of purposely misconstruing a student's statement can border on facetiousness.)

Another singularly effective technique for bringing the beginner to confidence in his own ability to *talk* mathematics intelligently is that of assigning to him an exercise, of unique interest, to be presented orally before the rest of the class. In his turn, he must stand on his own two feet and speak smoothly and self-confidently enough to convince a most critical audience—his fellow classmates. And during a question period that may follow, he directly displays his depth of understanding of fundamental concepts. There is no evasive sidestepping! And this technique, by its appeal to the competitive spirit of his classmates, very often produces amazing results in motivating other students to independent expression.

Of course, it is not by adherence to certain appropriate classroom procedure alone that the purpose of teaching the fundamentals of mathematics is achieved. The best routine is empty without those qualities, in the instructor, of contagious inspiration and depth of insight and cognizance of what is most-important.

Evident results are slow in coming. Indeed, it is almost paradoxical that the most lasting results of mathematics teaching are the most difficult to evaluate on the spur of the moment. But this much is certain: whatever time is spent in training our students to *talk* mathematics will be multiply repaid in all phases of our teaching. Without a firm grasp of vocabulary and concepts, our students can achieve no trustworthy progress.

THE METRIC SYSTEM

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War hastens trends and precipitates change! That there has been a trend toward the extended use of the metric system is evident.

The direct relation between wars and metric adoption is interesting to note. We all know that the Revolutionary War in France brought about the inauguration of the metric system in 1799. In 1871 right after the Prussian War in Europe, Germany, Austria, Hungary and their dependent states officially adopted the metric system almost doubling the population then on a metric basis. After the Civil War in this country there was great agitation for the system and its use was made legal in 1866 by act of Congress. After the last world war in 1920–21 the countries of Russia, China, Turkey and Japan went metric and by so doing more than doubled the population then on a metric basis. Now 55 out of the 57 countries of the world comprising more than 75% of the world's population are officially using the metric system.

Here we are confronted with the completion of another world war and agitation for metric reform has already taken on an increased activity. This renewed interest comes not only from educators and scientists but from engineers, manufacturers, merchants and military men not to mention magazines, newspapers and women's clubs as well.

Leaders in almost every field admit that the metric system is superior to the English system, but they differ as to the inconvenience and expense involved in making the change.

Here is where the public should be informed. That the changeover is not nearly as inconvenient or expensive as supposed is testified to by the fact that those who have made the change say the inconvenience is slight and the expense is more than compensated for in a short time by the increased efficiency in the organization. The time for the changeover would differ with different plants. In merchandising the change could be made in a very short time, requiring a modification of the scale beam in the weighing instrument only. In manufacturing there would be no change in manufactured parts, the change being made in the name of the size only. After several years at the will of the

manufacturer new units could be made in metric sizes as the old ones wear out. That there will be a temporary inconvenience is to be expected. Any great advance in improvement costs something. But the inconvenience caused by the use of the metric system would fade into negligible insignificance when compared with the present inconveniences in handling ration points and lack of cars and travel. Let it be understood also that the inconvenience now to those that have already made the change is prolonged as long as others in the country have not made the change necessitating two systems in use with their troublesome and *inconvenient* conversions.

A propaganda campaign of information should be launched over the United States stating the true advantages of the metric system. Very few lay people understand the metric system. They think it is a foreign system and like a foreign language would have to be learned anew with much labor and time.

The fact is that not only does the metric system *not* add anything new to the arithmetic of our system but it actually *takes out* the most difficult parts of our arithmetic. The operations with the common fractions which are a headache to most pupils would no longer be needed. In their place would be decimals in which the operations are like those of whole numbers. Thus, it may be said that the metric system reduces the operations of arithmetic to the operations of whole numbers.

The world is looking for simplification after the war. There is a Department of Simplified Practice recently organized in Washington, D. C. In the face of this simplification in all lines can we afford to continue to teach our children three systems of numbers when one simple one would suffice? The children in our schools are first asked to learn the operations with whole numbers. In the fifth grade or before when they have just begun to use whole numbers, but not with any degree of mastery, they are asked to learn the four operations with fractions and mixed numbers in each of which the operations of addition, subtraction, multiplication and division are different from those in whole numbers. Then before they have mastered the fractions they are asked to learn the four operations in denominate numbers where again the operations are different. Is it any wonder that the military authorities and the world of employers complain about the results in arithmetic! The metric system could be learned by our boys and girls as soon as they know their whole numbers and United States money which is already

decimalized. Thus in the interest of simplification of our arithmetic, which should be heralded by everyone, the question of metric adoption becomes paramount.

The following information should be broadcast to every man and woman in the United States.

The metric system offers three distinct advantages. They are:

First, Simplicity.

The three words, meter (m), liter (l), and gram (g), with the following six statements constitute the entire system:

Length	*Capacity*	*Weight*
10 mm = 1 cm	1000 cc = 1 L.	1000 g = 1 kg
100 cm = 1 m		1000 kg = 1 T
1000 m = km		

When this is compared with some 53 terms in numerous tables of measure in the English system the simplicity is apparent.

Second, Decimalization of all its units.

An illustration in two comparable examples will make this clear.

Druggists are often required to increase a formula to twice or more times the original.

(a) Let it be required to change 6 lb. 11 oz. 137½ grains to six times the quantity.

The following work is required;

6 lb.	11 oz.	137½ gr.
6	6	6
36	66	3
4	1	822
40 lb.	16)67 oz.(4 lb.	437.5)825.0(1 oz.
	64	437.5
	3	387.5

Ans. 40 lb., 3 oz., 387½ gr.

The above requires 45 figures not including abbreviations.

(b) A similar example in the metric system would be. Increase 6 kg, 977 g to six time the quantity.

The work required; 6.977 kg

6

41.862 kg Ans. 41 kg, 862 g.

This requires but 10 figures and the time and errors involved are more than proportionately reduced.

The saving is effected by the fact that the sub units in the metric system are all decimally related to the larger units reducing the multiplication to nothing but multiplication with whole numbers.

Third, Integral interrelation between the units of length, capacity and weight. A cube with an edge of 1 cm or 1 cc filled with water weighs 1 gram. An illustration again will clarify.

(a) Let it be required to find the weight of a tank of water that measures 4 ft , 6 in., by 2 ft., 3 in., by 3 ft., 4 in.

The work required may be done this way,

$4\frac{1}{2} \times 2\frac{1}{4} \times 3\frac{1}{3}$

$9/2 \times 9/4 \times 10/3$

$135/4 = 33\frac{3}{4}$ cu ft.

$33\frac{3}{4}$
$62\frac{1}{2}$

$\frac{3}{4}$
$16\frac{1}{2}$
$46\frac{1}{2}$
66
198

$2109\frac{3}{8}$ pounds

62
$\frac{3}{4}$

4)186

$46\frac{1}{2}$

The above requires 67 figures and a thorough knowledge of fractions. If the inches had not been simple fractions of a foot and dimensions changed to inches more work would have been required.

(b) A similar example in the metric system would be:

Let it be required to find the weight of a tank of water 4.6 m by 2.3 m by 3.4 m.

The work is shown here.

4.6
2.3

138
92

10.58
3.4

4232
3174

35.972 cu m or 35.97 metric tons or 36 T (rounded to 2 sig. fig.)

But 33 figures and no fractions are required in the above.

The advantage above is gained by having a one-to-one correspondence in the unit of capacity and weight. One cu m weighs one metric ton.

If we are ever going to change to this simple system there will never be a more opportune time than now.

There will be a metric bill before Congress this fall. We need the support of every organization that is interested in the cause. The United States must take the first step because we already have a decimal currency. England would of necessity follow.

A set of strong resolutions favoring metric usage put forth by every interested organization in this country would help greatly in putting the necessary legislation across.

The last metric bill in 1926 lacked but a few votes in passing due to a pressure group of German interests who were eager to keep the bulk of the trade with Latin America for themselves.

Let us hope that among the reconstruction measures after this war the United States will adopt some form of metric reform with a universal language of measurement as the goal.

AIRLINE TRANSOCEANIC CROSSINGS

One airline flying under contract to the AAF Air Transport Command has averaged more than a million miles a month for the past two years on the transoceanic routes connecting Newfoundland, Iceland, Scotland and North Africa. Averaging more than 13 flights a day, and bringing the total now to amost 3,500, these flights have been accomplished without a serious accident and without the loss of a single plane, despite the fact that on many occasions each plane was kept in the air almost 12 out of the 24 hours.

American Airlines is just one of the several U. S. air transport companies operating under an ATC contract. Other companies have achieved equally spectacular records.

All planes operated by American Airlines are four-engine transports, convertible into litter ships. During one month a total of 5,253 passengers were carried, eastbound or westbound, over the Atlantic. On most flights returning from the British Isles, wounded servicemen are brought back for medical treatment in the United States. Hundreds of bags of mail from the boys at the front share space on every flight.

The development of the Air Transport Command has been materially assisted by the use of existing civil air carriers. Its work has helped turn the tide of many a battle. When Rommel was making his attack at Cairo, Allied supplies of anti-tank ammunition were short at the Egyptian city. Tons of this ammunition were flown from the United States to Cairo by the ATC through exceptionally bad weather in three days.

An outstanding operation of the Air Transport Command is the supply of vital war material to the armies and flying units operating in China. Since the closing of the Burma Road in April, 1942, the only link between China and the other United Nations fighting Japan has been the air route from India over the Himalaya mountains.

ATC routes, operated by civil airlines, connect every continent on the globe, with eight ATC ports of aerial embarkation in the United States, which function in much the same way as the Naval ports of embarkation, but on a smaller scale.

CLEAR AS A BELL

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For years I have attempted eagerly and quite futilely to obtain a general knowledge of the technical fields of optics, aeronautics, thermodynamics, etc. With buoyant enthusiasm I have seized books from the shelves of the public library or the Engineers' Club, and when with the passion for knowledge burning in my soul I have opened the books and scanned their pages, I have found that

$$\int (x^2-y^2)dy+(a_1-a_2)^{\log e}+\int a-mdy.$$

After gazing with dismay at the profound truths indicated in the above expression I have trudged disconsolately back to the public library or the Engineers' Club, and with my inferiority complex boosted several notches have furtively deposited my books and got out a copy of *Peter Rabbit.*

It would seem that a teacher of engineering, optics, mechanics, or electricity in our colleges does not know how to express himself except in mathematical formulas. While in certain technical departments mathematical formulas are indispensable tools, it should be possible to explain in lucid language for the general reader the fundamental principles of science.

With this thought in mind I am composing a little essay to show how an ordinary intelligent human being would discuss a topic, and then how the mathematical scientist would proceed to render it unintelligible.

A

The falling off in church attendance has been a matter of concern to many thoughtful people, particularly the ministerial profession. No doubt many causes contribute to this decline, of which the changing temper of the times with its emphasis on things material rather than spiritual is an important one. However, the increasing strenuousness of modern life should not be overlooked. Sunday is for many business and professional men the only time to relax from the almost intolerable strain that modern life imposes upon them. They feel that a day spent wandering over a golf links under a clear blue sky is worth as much as a session in church with its confined and highly conventionalized atmosphere.

No doubt on occasions the weather plays its part in contributing to small church attendance, but as this is only an occasional factor its importance should not be exaggerated.

B

In considering the problem of church attendance we must begin with Scheiffenschnozzle's well known law which indicates the frequency of occurrence of Sunday: $T/7$, T representing time expressed in days. This formula has been observed to hold true as a result of a long period of observation, and can also be derived from theoretical considerations. Considering time as varying over a certain interval we have $T/7dT$. Integrating we get

$$\int \frac{T}{7}\,dT = \frac{1}{14}\,T^2.$$

The worst offenders in the matter of church attendance are the male portion of the population. This fraction of the population may be expressed as follows: $P/2$, where P is the population. This is only an approximation but for practical purposes is sufficiently accurate. Inasmuch as the extremely youthful elements of the population do not enter into our consideration of the problem we have:

$$\frac{P}{2} - \frac{p}{2}.$$

Since a very large fraction of the non-church going males play golf on Sundays we have:

$$\left(\frac{P}{2} - \frac{p}{2}\right)^{\log (1/14)T^2}, \tag{1}$$

log (or wood) representing the golf club.

There is another variable that enters into this problem—namely the weather, and what a variable! Let W represent the weather, and since weather is a continuous variable we will represent it as a differential; $W\,dt$. Integrating we have $\int_R^S W dt$, where R represents rain and S, snow. (2)

Combining functions (1) and (2) we get

$$\int_R^S W dt + \left(\frac{P}{2} - \frac{p}{2}\right)^{\log (1/14)T^2}.$$

And so we see there aren't enough people going to church on Sundays.

DEMONSTRATIONS WITH SOLID CARBON DIOXIDE

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Solid carbon dioxide, dry ice, can be used easily for a number of low temperature demonstrations. A mercury hammer can be made, rubber tubing becomes brittle and breaks, flowers freeze and shatter, and several common gases are successfully liquefied. Dry ice also furnishes a good source of gaseous carbon dioxide. Consequently, the experiments ordinarily performed with this gas from steel cylinders or generators, can be performed with a few grams of dry ice.

Dry ice was rather common in the home before the war, as ice cream was frequently packed in it for bulk delivery. After the war, it will doubtless again become plentiful. Consequently, practical lessons in safety should be taught while demonstrating with it. Accidents have resulted from pranks when dry ice was sealed in glass containers with a little water. Children and adults alike should learn that confined gases exert a pressure which is dangerous, unless properly handled. The careless handling of this commodity, which is much colder than water ice, may cause serious "burns." These so-called "burns" are really frost bites caused by the low temperature, $-78.5°$ centigrade, of solid carbon dioxide. Dry ice should not be put in drinking water to cool it, as the swallowing of small undissolved particles could result seriously.

In demonstrations for assemblies or open house programs it is suggested that the lecturer discuss briefly the commercial sources of carbon dioxide gas and the reasons for the use of the solid product. It is a by-product of blast furnaces, lime kilns, and distillery vats. Many of the natural gas wells of California, Colorado, New Mexico, Utah, and Washington are sources of gaseous carbon dioxide. Where none of these sources is readily available, coke is burned to secure the gas for purposes of liquefaction or solidification. Over 175,000 tons of solid carbon dioxide were produced in the United States in 1941. The advantages of dry ice as a refrigerant are (1) certain foods keep better in the dry atmosphere of gaseous CO_2 than in moist air, (2) the amount of space required for shipping some commodities is materially lessened, and (3) there is no danger of ruining other

merchandise by its melting. Ice cream, for example, can now be shipped in cartons instead of large buckets packed with ice and salt. Fish and quick-frozen foods are also shipped with dry ice as the refrigerant. Dry ice is still more expensive than water ice, and the number of calories of heat absorbed by a pound of it are approximately twice the number absorbed by a pound of water ice in melting. Under favorable conditions, though, it is claimed that the insulating blanket of dry CO_2 really makes a pound of dry ice as effective a cooling agent as from 10 to 15 pounds of water ice.

Securing and Handling Dry Ice

In normal times, stores that sell bulk ice cream will usually provide a few lumps of dry ice at a moderate price. In cities, it may be purchased direct from the regular supply sources. Ten cents worth of dry ice should perform all experiments for one occasion, as it usually costs, in small quantities, about three cents a pound. The lumps should be carefully wrapped in paper and transported in either a paper bag or card board box. The more carefully you insulate the lumps the longer they will last. A three pound lump, well insulated, will furnish considerable dry ice even after being stored for twenty-four hours.

Heavy cloth gloves enable one to handle dry ice safely without danger of frost bite. Laboratory tongs, forceps, and a large spoon may also be of use in certain experiments. The wiser practice is not to handle it with bare hands!

A satisfactory freezing mixture is made by placing about 150 grams of dry ice in a 400 cc beaker and slowly pouring about 100 cc of ethyl alcohol over it. This mixture is effective for at least 30 minutes. It is quite economical, as probably 75 per cent of the alcohol can be decanted for further use. The dry ice used gives satisfactory results if broken into pieces about the size of a number two rubber stopper. Of course, both acetone and ether could be used in place of the alcohol, but they are not recommended owing to their volatility and inflammability. Solid carbon dioxide is surrounded by a layer of gaseous CO_2 which to some extent protects one's hands. No such protection exists with this freezing mixture, so be especially careful and keep your hands free of it.

Making Solid Carbon Dioxide

If a comparatively full cylinder of compressed CO_2 is avail-

able, dry ice snow can be readily made. This is a graphic experiment, but it is less economical than purchasing dry ice for further experiments. The usual process is to lay the large steel cylinder on a stout table or lecture desk in such a manner that the end provided with an outlet extends over the table edge. Raise the bottom by means of a wooden block, this allows the liquid to run more rapidly towards the outlet. Tie a small black woolen bag or several thicknesses of heavy cloth over the outlet. Open the stopcock for two or three minutes. There will be considerable commotion as the gas rushes out. Close the stopcock, remove the bag and carefully turn it inside out. A visible amount of snow will have collected in the bag. The evaporation of liquid CO_2 and the expansion of the gas absorb so much heat that about 10–15 per cent of the CO_2 changes into the solid form. Small cylinders of CO_2 may be purchased for such demonstrations as this one.

Preparation of A Mercury Hammer

An easy way to perform this demonstration is to make a hole in a two or three pound lump of solid carbon dioxide with a pen knife or other suitable instrument, large enough to contain the desired amount of mercury. Carefully pour the mercury into this excavation and in a minute or so insert a piece of wood about the size of an ordinary lead pencil for the handle. Within a few minutes, depending somewhat on the size hammer desired, the mercury will be frozen. One can easily drive a tack into a soft wood plank with the hammer. When it begins to show signs of returning to the liquid state it can be placed either in a beaker or in a funnel which extends into the regular supply bottle of mercury.

If the lumps of solid carbon dioxide are not large enough to follow the above procedure, the mercury can be poured into a small pasteboard pill box through which a hole for the handle has been made. This can then be immersed in the freezing mixture described earlier. After freezing the mercury, the box should be peeled from the hammer. Mercury freezes at about $-40°$ centigrade.

Freezing Rubber Tubing and Flowers

Rubber tubing after staying a short time in a beaker of dry ice and alcohol becomes hard and brittle. It will break if placed on the table top and struck with a hammer. After thawing the rubber resumes its elasticity.

Flowers, such as carnations, when immersed in the solution of dry ice and alcohol quickly freeze and readily shatter.

Liquefaction of Gases

Such gases as sulphur dioxide, ammonia, and chlorine may be liquefied at normal atmospheric pressure. Each gas should be dried as it comes from the generator. The receiving receptacle, flask or test tube, if immersed in the freezing mixture already described soon contain a liquid product. Sulphur dioxide changes to a liquid at $-10°$ centigrade and is consequently the easiest of the three to liquefy. There are several interesting experiments which can be performed with such liquefied gases.

Sublimation

If the irregular side of a lump of dry ice is placed against a marble slab or the soapstone desk top a decided chatter is heard. A smooth, flat side does not give as much noise as an irregular or rough surface.

Press a quarter of a dollar against a piece of dry ice. There is a pronounced squeal until the money becomes cold.

Place the handle of an all metal knife or a tuning fork against a piece of dry ice. A high pitched buzzing sound results.

In each of the above cases gaseous CO_2 was responsible for the sound. This gas leaving a solid, without passing through the liquid state, indicates that sublimation has occurred.

Inflating a Toy Balloon

Place several small pieces of solid carbon dioxide in a stout test tube which has a lip. Cover the mouth of the test tube with a small rubber balloon. Tie the balloon in place if necessary. It soon inflates and will burst after some minutes.

The Burning Candle Demonstration

Place several small lumps of dry ice in a dry beaker or wide mouth bottle. Light a candle and stand it in a beaker or use a regular candle stand. After a short pause pour the invisible, gaseous contents of the beaker over the flame. Of course, the flame is extinguished. Several properties of CO_2 are shown. This experiment can be made more interesting by arranging a series of candles in an inclined trough and pouring CO_2 down the incline. The candles are extinguished in sequence as the gas reached them.

Burning Magnesium in CO_2

If a strip of ignited magnesium ribbon is held in a jar of CO_2 it continues to burn. Flakes of carbon and also white magnesium oxide appear. $2Mg+CO_2 \rightarrow 2MgO+C$. The activity of magnesium explains this action. This demonstration is easily performed by placing several small pieces of solid carbon dioxide in an eight ounce bottle which has a wide mouth. Forceps are used to hold the magnesium strip.

The Volume of a Gas from a Solid

This is not necessarily a quantitative experiment, but with a 500 or 1,000 cc graduate filled with water and immersed in a battery jar of water, it is interesting to see about 1 gram of solid CO_2 displace approximately 500 cc of water. The piece of dry ice sinks to the bottom of the battery jar and the graduate can easily be moved to catch the escaping gas.

"Smoke" for Air Foil Experiments

Fit a wide mouth 8 ounce bottle with a one-hole rubber stopper provided with a short, right angle glass delivery tube 7 or 8 mm in diameter. Place several lumps of dry ice in the bottle and add a little water. Replace the delivery tube and a stream of vapor comes from it. This vapor can be directed into the current of air from a fan which passes around the air foil as suspended in the wind tunnel. Warm water gives more "smoke" than cold. As the action slows up more warm water can be added to the generator.

The Alcoholic Content of a Winterized Car Radiator

While not spectacular, this experiment has practical value. Place about 10 cc of the solution from your winterized automobile radiator in a test tube. Insert the test tube in a beaker of dry ice and alcohol as previously described. Place a thermometer in the test tube and with stirring determine when slush forms. You now know what temperature your car radiator will withstand.

A Mystery Jar

This demonstration should not be performed before a scientific audience, but before a popular audience, it is of interest. Place a spoonful of crushed dry ice or snow in a dry glass jar. Have a similar untreated jar which is naturally filled with air.

Place a lighted splint in the jar of air and it continues to burn. Place the splint in the prepared jar and it, of course, goes out. The powdered dry ice is inconspicuous in the jar or one may wait until it all changes into gaseous CO_2.

Assembly or open house programs making use of such demonstrations as outlined and the many many others which lend themselves to public programs frequently stimulate interest in science and result in an appreciable increase in enrollment in elective subjects. Science teachers, even though committed to individual laboratory work, should also perform frequent demonstrations for their classes. Certain of the above experiments can be used satisfactorily for class demonstrations. If demonstrations are relevant to the subject, carefully planned, quickly and successfully executed, it is next to impossible for the teacher to overdo them. Not only are they an excellent teaching device, they also offer an opportunity to show students good laboratory technique. The author believes in more and better demonstrations to supplement individual laboratory, but not to replace it. We learn best by doing. The laboratory is an excellent place for doing and for learning when the experiments are functional and challenging.

A METRIC RESOLUTION PROPOSED FOR ADOPTION BY THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

WHEREAS, the advantages of the metric system, well known to scientists and mathematicians, would be in harmony with the simplification procedures which will be a part of the post-war reconstruction program, and

WHEREAS, the metric system takes out the difficult part of the arithmetic from our measuring systems, namely the common fractions, and

WHEREAS, the metric system reduces all necessary computation in measurement to the operations of whole numbers, thereby greatly simplifying the learning of arithmetic by children, and

WHEREAS, there has been a long steady trend in metric adoption by 55 of the 57 countries of the world and war hastens trends, and

WHEREAS, there is no probability among the nations now on a metric basis of going back to the English system, thus necessitating the use of two systems with the accompanying inconvenient conversions instead of one simple system, and

WHEREAS, the close of this war will permit an opportunity never before presented, and, we hope, never again to be repeated, when customs and habits have been torn loose from their ruts, therefore, be it

RESOLVED that the Central Association of Science and Mathematics Teachers go on record as favoring some form of legislation for immediate metric usage in those lines most feasible for metric adoption.

A SIMPLE AND PERMANENT APPARATUS FOR DEMONSTRATING CONDUCTIVITY OF ELECTROLYTES

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The electrical conductivity of polar molecules is a phenomenon which is at once fundamental and interesting. It therefore rightfully finds a place in so elementary a treatment of chemistry as is given in the usual high school course. Yet the demonstration of this property of electrolytes must suffer from the lack of suitable apparatus.

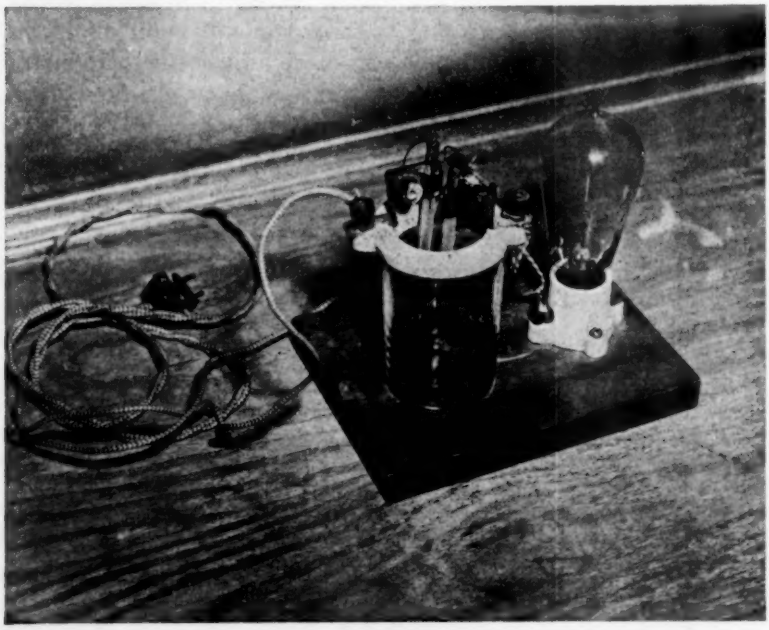

FIG. 1. An old form of apparatus

Various arrangements have been proposed for showing the electrical conductivity of ionizable compounds. One very old form consists of a drinking tumbler upon which rests a procelain collar, serving as a mount for a pair of glass-encased mercury electrodes the ends of which are short lengths of platinum wire,

sealed into the glass. This apparatus suffers from the fact that it is clumsy, easily upset and uses a large volume of electrolyte. In addition it necessitates pouring from a wide-mouth vessel to a narrow-mouth bottle, when the particular liquid used is to be returned to the original container at the end of the demonstration. Furthermore, if one wishes to show the effect of dilution upon conductivity, use of this apparatus results in wastage, by dilution, of a sizeable quantity of electrolyte, not to mention the danger involved if sulphuric acid is chosen for this demonstration. Most teachers will want to demonstrate the behavior of anywhere from three to six compounds. This results in the additional annoyance of washing the tumbler and the electrodes, and, for some demonstrations, even drying them.

Most, though not all of these disadvantages are overcome by the type of apparatus which consists of a set of bottles containing solutions of electrolytes or non-electrolytes. These are fitted with rubber stoppers which serve as mounts for mercury-filled, platinum-tipped glass electrodes. The circuit, including the lamp, is closed by immersing the wires from the lamp into the mercury electrodes. The disadvantages of this apparatus are that the bottles may be tipped over, spilling the mercury, or the wires from the lamp may be accidentally brought too close to each other, causing a short circuit. Mounting these wires on a small piece of fibre-board at such a distance from each other as to fit automatically into the mercury electrodes obviates the possibility of a short-circuit.

One very desirable feature, not possessed by either type of apparatus discussed above, is the possibility of comparing the varying degree of luminosity of the lamp produced by different electrolytes. As alpha,* the degree of dissociation, differs for different electrolytes, it is a great advantage to be able to show that this difference is observable in the conductivity demonstration. Where, however, only one lamp is used in the apparatus, the teacher must rely, as he goes from one electrolyte to another, upon the students' recall of how brightly the lamp glowed for each of the tested liquids. The apparatus about to be described has the advantage that each of the six liquids in the demonstration has its own lamp and all liquids are tested simultaneously so that it is possible to observe relative conductivity. In addition the apparatus is inexpensive, compact, easily

* The most recent refinements in the ionization theory are beyond the scope of the elementary course and are therefore not considered here.

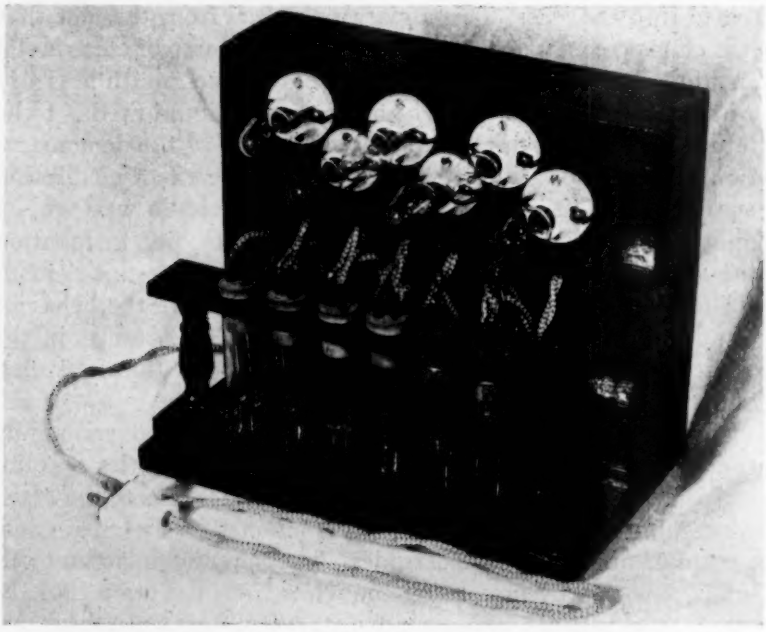

FIG. 2. Courtesy of Mr. Mook Hagmann, Philadelphia

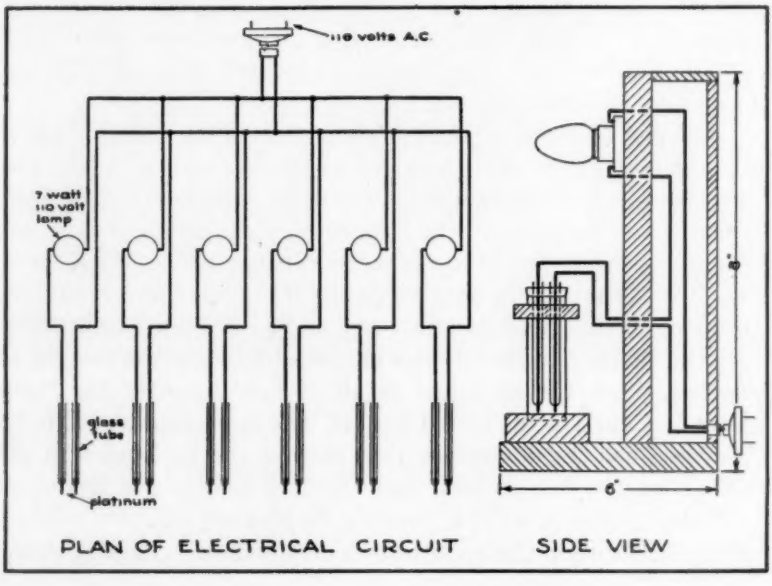

FIG. 3. Wiring diagram of above apparatus

portable, does not have to be washed, dried nor constantly recharged, nor does mercury produce any problem, as none is used in this design.

A wooden test tube rack, of standard design, with a capacity of a half dozen six-inch test tubes is nailed to a base board of half-inch stock. The hemispherical depressions at the base of the rack which normally accommodate the bases of the test tubes are enlarged by means of a suitable wood-bit as so to permit the glass cells to fit and rest therein.

A box, of the design and dimensions shown in Figures 1 and 2, is so constructed that the back is easily removable for repairs, should these ever be necessary. The front and sides of the box are made of half-inch stock, while the top and back may be of one-quarter-inch material. No bottom is needed. This box is fastened to the same base-board, in back of the test tube rack, as shown in the illustrations.

The cells are six ordinary 15 cc. medicine vials, fitted with two-perforation No. 2 rubber stoppers, bearing in each perforation a piece of 3 millimeter internal-bore glass tubing. Two of these six stoppers are cut away vertically to about one-third of their width, so that when fitted into the vials, a wide opening is left. This is to permit dilution of electrolyte without removal of stopper. The electrodes consist of pieces of soft telephone cord, around the uninsulated ends of which one-inch pieces of platinum wire have been very carefully and tightly wrapped, leaving as much as possible of the platinum wire for sealing into the glass tubing and protrusion beyond the end of the tube to the extent of 5/16 of an inch.

The telephone cord is of such length as to create a goodly amount of slack between the top of the vial and the front of the box. The purpose of this slack cord is to permit removal of the vial for recharging or cleaning.

A rubber band may be passed around the test tube rack half way between top and bottom so as to keep the vials more securely in their places, if this is found necessary. The cells may be easily removed from the rack by lowering the rubber band, lifting out the stoppers and then lifting the vials out backward into the space between rack and box.

The six lamp-sockets, each bearing a 7 watt lamp, are fastened to the front of the box in two rows of three each, thus saving space, and making it easier for the eye to associate a given cell with its lamp. The lamps and cells are connected in a

series-parallel arrangement and placed across a 110 volt line by means of a common plug (see illustration 2).

The following electrolytes, in five cc. quantities, are used in the glass-vial cells:

1. Concentrated hydrochloric aicd
2. Ten per cent sodium hydroxide solution
3. Ten per cent sodium chloride solution
4. Ten per cent sugar solution
5. Concentrated ammonium hydroxide
6. Glacial acetic acid

To use the apparatus for demonstration, the teacher merely plugs the apparatus into a 110 volt line.

The lamps attached to the cells of the first three electrolytes burn very brilliantly. No illumination is, of course, visible with sugar solution. The lamp connected with ammonium hydroxide produces a very dull glow. Glacial acetic acid, like sugar, allows no visible illumination and students immediately conclude that these two compounds are non-electrolytes. At this point in the demonstration the ammonium hydroxide and glacial acetic acid are diluted with water by inserting the capillary end of a long dropping pipette into the opening in the stopper of each of the cells containing these electrolytes. The effect of dilution upon each of these is very striking. Due to increased ionization both lamps glow brightly.

A ten inch pipette may be made by drawing out a piece of glass-tubing to form a capillary at one end. The other end is flattened somewhat so as to produce a shoulder over which a rubber aspirator bulb of about one inch diameter is passed. Such a pipette produces very vigorous stirring action in the cell.

The apparatus described above may be used with gratifying results for demonstrating the conductivity of electrolytes. By using weakly dissociated compounds in the demonstration, a carry-over may be made to the subject of hydrolysis. Still further applications of this apparatus may suggest themselves to other teachers.

A research problem is not solved by apparatus, it is solved in a man's head. The laboratory is the means by which it is possible to do the solving after the man has the idea clarified in mind.—CHARLES F. KETTERING.

A BRIEF HISTORY OF PHOTOGRAPHY

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Although photography in a practical sense is only a little over a hundred years old, it has made great progress during that period and especially is this true in the past two decades. However, certain observations about light, optics, and photochemical changes go back many hundreds of years. Application of observed facts, study of chemical action, and good correlation between theory and practice have made photography very useful in the modern world.

Numerous ideas about natural phenomena held by people of earlier centuries seem very strange to us today. Opinions held by Plato, Aristotle, Pythagoras and other teachers of their times were accepted by the public and such ideas held sway for centuries. However, a very limited amount of experimenting would have resulted in better understanding of natural phenomena, and removed the frequent notion that observed events were supernatural. However, in some instances the theories and explanations of phenomena were correct. A good example was the study of buoyancy of floating bodies as studied by Archimedes.

According to Plato in the 5th century B.C. the sighting of an object was explained as follows: Sight results "when a stream of light (divine fire) emanating from the eye mixes first with the light of the sun and then with an emanation from the body seen."

Some early peoples held that the eye of man extended invisible "feelers" or tentacles which contacted objects and resulted in vision. Others held that the eye sent out emanations. Pythagoras in the 6th century B.C. held that sight depended upon minute particles emanating from objects and entering the eye.

In the 4th century B.C. Aristotle rejected all of the previous theories of sight, and contended that light is a mere power or quality propagated through a medium which he called the "pellucid."

In spite of all such theories it was believed for a period of about 1,600 years that sight depended upon something going out from the eye of the observer. In the 11th century A.D. the Arabian astronomer, Alhazen, clearly stated that sight is excited by something which enters the eye.

The corpuscular theory of light was held by Sir Isaac Newton, but Aristotle seems to have had an inkling of the modern wave theory of light.

Certain optical phenomena and chemical effects of light were observed and recorded in ancient times. Tanning of the skin, the fading of colors of fabrics, and the pale color of plants which were kept in dim light were noted at least as early as 300 years B.C. Aristotle and Euclid knew of the formation of images of objects when light was passed through small holes in opaque walls. In 350 B.C. Aristotle noted the round image of the sun upon the ground when sunlight passed between the leaves of a tree. This was the principle of the "camera obscura." Use of this apparatus was recorded by Roger Bacon of England in the year 1267, by Alberti in 1437, and by the Italian artist, Leonardo da Vinci, in 1500.

The camera obscura was used by artists in making outline sketches for their paintings, and it seems that a crude lens was used in such an apparatus in Italy and described by Barbaro in 1568. The astronomer Kepler assisted in the optics of the camera obscura, but refraction of light seems not have been clearly described until 1611.

The action of light in darkening mineral silver chloride (horn silver) was described by the alchemist Geber in the 8th century, and again by Fabricius in 1556. The latter lived in Saxony.

The darkening of silver nitrate by light was noted and described in 1727 by the German physician, Johann Heinrich Schultze. He accidentally spilled some silver nitrate solution upon chalk. During the afternoon he noted a darkened image upon the chalk, cast by the sunlight and the shadow of the window sash. Schultze soon produced "light drawings" by the action of sunlight upon silver nitrate, but he said he had "no way of fixing" the images which he produced.

In England in the year 1763, Dr. Wm. Lewis printed dark images upon bone, ivory and wood by coating the objects with a solution of silver nitrate and exposure to light. It seems probable that Lewis learned of the work of Schultze through an account written by Joseph Priestley, the British chemist who discovered oxygen, and who spent the latter part of his life in Pennsylvania.

After the death of Lewis in 1781, his notes on experiments came into the possession of Josiah Wedgewood, the maker of famous "Wedgewood ware." Wedgewood's son, Thomas, was

an invalid who was a student and experimenter. Young Thomas was evidently of a thoroughly scientific type as evidenced by his membership in a scientific society. In the latter he was associated with the chemist, Priestley, astronomer Wm. Herschel, physicist Jas. Watt. (inventor of the steam engine), and Dr. E. Darwin (the father of Chas. Darwin.)

Young Wedgewood was a friend and associate of Sir Humphrey Davy, and in collaboration with him, he gave a paper before the Royal Institution of England in 1802 under the title, "On an Account of a Method of Copying Paintings upon Glass, and of making Profiles, by the Agency of Light upon Nitrate of Silver."

Davy proved that silver chloride would darken more rapidly than silver nitrate under action of light, but all of his attempts to "fix" the image and render it permanent by coatings of varnish resulted in failure. So, he lost interest.

Meanwhile, in 1777, the Swedish chemist Scheele proved that silver chloride would darken most quickly when put in the violet part of the spectrum (prismatic colors) and further that chlorine was set free at the same time. He showed also that most of the exposed silver halide would dissolve in ammonium hydroxide, leaving a slight residue which seemed to be silver. Thus, Scheele was on the trail of the nature of the latent image.

Infra-red light was discovered by astronomer Herschel in 1800 by use of a thermometer beyond the visible red region, and ultra-violet light was discovered by Ritter in 1801, by the darkening of silver chloride when it was placed beyond the visible violet.

While modern photography owes much to the work of both Davy and Wedgewood, the first practical processes were based upon the findings of the Frenchmen, Niepce and Daguerre.

Joseph Nicephore Niepce was a wealthy country gentleman who enjoyed experimenting. He used a camera obscura and was attempting to find a lithographic process. As early as 1822 Niepce could print an image and fix it. He found that Bitumen of Judea (Jew's pitch) would become insoluble in oil of lavender when it had been exposed to light. Niepce used asphaltum upon glass, but the long exposures needed made the process impractical. Through an optician friend in Paris, Niepce was introduced to the well-known painter of theatrical scenery, Louis J. M. Daguerre. The latter used a camera obscura in his art work, and the two men decided to work together on the production of

permanent images by chemical means. Niepce died in 1833, but his son continued on with Daguerre.

In a search for light-sensitive materials Daguerre produced a thin layer of silver iodide on a silver plate by exposing the latter to fumes of iodine. This seems to have been done in 1831. The silver iodide required long exposure to produce darkening, and there was still no method of fixing the plate to render the image permanent. Daguerre continued his experiments. In the late summer of 1837 he exposed a silver iodide plate in an attempt at a landscape. The sky clouded, the light failed, and Daguerre was disgusted. He set the plate in a closet, with the intention of re-polishing it for further use, but he overlooked an open dish of mercury that was in the closet. When Daguerre went for his plate he found a visible image of the landscape upon it. The vapors of mercury had developed an invisible image to make it visible. Daguerre had discovered the latent image and the means by which to develop it to a visible form. His discovery had lowered the necessary exposure to light from hours to minutes. It had made photography a practical process. Further, Daguerre could "fix" the image by dissolving away the unexposed silver halide by strong brine or by a solution of a soluble cyanide. In the Daguerreotype process the mercury would condense upon the latent image. Apparently the mercury deposited on the silver of the image which had resulted from exposure to light.

Improvements were made in the Daguerreotype process. To save cost, a copper plate was coated with a thin layer of silver. Greater sensitiveness was attained by using bromine in place of iodine for sensitizing the silver surface with fumes of the halogen. In 1819 the British astronomer Herschel introduced sodium thiosulfate (now known as "hypo") for use as a fixing agent.

Daguerre and his partner were not only good experimenters but they had an eye for business as well. Through the aid of the French astronomer, Arago, the Government of France was persuaded to buy the Daguerreotype process and make its details public. This was done in August 1839. The process was the chief one in general use for portraiture until 1851, or even later.

Although each picture produced required an exposure in the camera and no prints could be made, yet the Daguerreotype portraits were of excellent quality. Many are still in existence.

The Daguerreotype process seems to have been introduced

into the United States in March, 1840, when Robert Cornelius and Dr. J. W. Draper photographed Draper's sister.

While Daguerre and Niepce were experimenting in France other processes of photography were evolving in England. Wm. H. Fox Talbott had a silver chloride paper for prints as early as 1835. He made an independent discovery of the latent image on September 20, 1840. Talbot made a paper that was sensitized with silver iodide, and after exposure he developed the image by a solution of gallic acid. Talbot was the first man to make a negative by exposure and development, and then to make a print from it. He patented his print process under the name of "Calotype" (also called Talbotype). Talbot's findings were presented to the Royal Society of England by the scientist, Michael Faraday.

Since paper negatives were not transparent, and also showed grain of the paper, search was made for a clear support medium for the silver salt. These defects were eliminated in 1847 by the work of a Frenchman, Niepce de Saint Victor, who was a nephew of the earlier Niepce. He produced an emulsion of albumen and potassium coated upon glass and then sensitized it by use of silver nitrate. Development was done by gallic acid, derived from oak bark.

This process was a step in advance, but the poor keeping qualities of albumen led to the use of collodion in its place. In making emulsions the iodized collodion was poured onto the glass plate and the solvent alcohol-ether allowed to evaporate, after which the plate was sensitized by a short treatment in a solution of silver nitrate. Such plates came into use in 1851, and they ended the reign of Daguerreotypes. The wet collodion process was in general use until about 1876, and it is still used somewhat by photo-engravers. Negatives by this process are of fine grain and yield good prints. One defect of collodion emulsions is their extreme slowness, or low sensitivity to light. This is the chief reason why gelatine emulsions have replaced collodion emulsions. A "fast" collodion emulsion has never been produced.

For the sake of convenience, attempts were made to use dry collodion plates, but they were still less sensitive. Development of collodion plates was done by use of ferrous oxalate dissolved in potassium oxalate, the ferrous iron acting as reducing agent to deposit silver in the emulsion. Scott Archer of England had much to do with improving the wet collodion process but he did not patent his findings.

Prints from wet collodion process negatives were made by use of salted sensitized paper, as in the calotype process, but about 1850 there came into use photographic papers that were coated with albumen emulsions that were sensitized by use of silver nitrate. Albumen-emulsion print papers were in general use from about 1850 to 1890. Prints on such papers are made by "printing out" by direct action of sunlight, or other very strong light. The tone of such a print is red-brown, and of the type seen on portrait proofs. In order to secure a more pleasing color on the print, the latter is usually toned by use of a solution of gold chloride. Part of the silver on the print is replaced by gold.

For use in making plate emulsions gelatine replaced both albumen and collodion, and this has also been true of print paper emulsions. One important reason for use of gelatine is that it permits production of emulsions of much higher speed or sensitiveness.

Photographic gelatine is a mixture of very complex organic compounds. It is obtained by steam-cooking and extracting hides of animals, bone marrow, etc. The presence of minute traces of organic sulphur compounds in gelatine very greatly raises the sensitivity of the resulting gelatine emulsion. These sulphur compounds may be extracted from black mustard seeds and used to activate gelatine.

In the year 1878, Bennett of England found that if a gelatine emulsion of silver bromide (or other halide) were kept warm for a few hours its sensitiveness was increased. This process is known as "Ripening." It has to do with size of grains of silver halides and the formation of the most sensitive modification of the halide. Monckhoven found that addition of ammonia would increase the emulsion sensitiveness even more, if used during ripening.

Another important discovery was made by Professor Vogel in Germany in 1873. He was using dyes on collodion plates to reduce the blurring defect known as Halation. He noticed that the red dye, eosin (often used in red ink), caused the emulsion to be distinctly sensitive to colors to which ordinary silver bromide responds very poorly. The use of dyes in gelatine emulsions followed the work of Vogel.

Silver bromide is normally sensitive to ultra-violet, blue, and blue-green light. By adding suitable dyes the sensitiveness may be extended into the yellow of the solar spectrum. Such emulsions are called *orthochromatic*. By the use of a mixture of

dyes the sensitiveness of an emulsion may be extended to orange and red, thus covering the whole spectrum. Such emulsions are known as *panchromatic.*

During recent years the production of new dyes has resulted in two important advances in photography, as follows: (a) greatly increased speed (sensitivity) of emulsions; (b) extension of sensitivity into the infra-red region.

Emulsions that are sensitive to infra-red have varied and important uses. They are useful in study of varicose veins and skin cancers, and in detection of forgeries of documents. Since infra-red light penetrates haze readily, the use of infra-red emulsions is very important in military photography, aerial surveying, and aerial mapping operations. By use of infra-red films mountains, invisible to the eye, have been photographed at distances of over 300 miles. Other uses are in cloud photography and landscape work.

George Eastman began photography as an amateur, but he soon recognized that cameras and glass plates were too cumbersome for use by the public. He founded his company with the idea of making photography popular and of use by large numbers of people. Roll film and the loading of a small camera in daylight, without use of a dark room, did much to make the public camera-conscious. Roll film was invented and patented by a preacher, Reverend Goodwin, who sold the patent to makers of film. The use of cut films followed roll film. Since about 1912 there has been a marked tendency toward the use of smaller cameras fitted with excellent lenses, and to the use of films instead of plates. These changes make for portability of equipment, decreased cost of operation, and the sharp, clear-cut negatives permit enlarged prints from small negatives.

X-ray photography with its many uses followed the discovery of X-rays in 1895. X-ray work contributes much to medical diagnosis, detection of flaws in metal castings, study of the structure of molecules of matter, and in other activities.

It has long been the goal of photographers to make transparencies (lantern slides or movie films) in natural colors, and also to make prints in natural colors. Both of these things have been accomplished. Kodachrome, Dufaycolor, the Finlay process, etc., make transparencies in color. Some of these processes are fairly simple while others are more complex and require that the exposed film shall be processed by the manufacturer who has at his disposal extensive and elaborate equipment.

Prints in natural colors may be made by the Chromatone Process of the Defender Company, or by Wash-off Relief Process of the Eastman Kodak Company. Other processes are also in use.

The whole field of color photography is under very careful study at the present time and it is likely that color processes will be greatly simplified, with resulting extensive use by the public in the post-war period. At present color film finds extensive use in the war zones, especially by Air Corps photographers.

From small beginnings the movie industry has grown to great extent. It is estimated that the United States has close to 30,000 movie theaters and that the weekly attendance in movie shows equals about half the population of this country. An industry on such a scale evidently has enormous possibilities for general education and uplift, and great influence for good or for evil. Experts state that 85% of what we know comes from what we see. So, recording of what is to be seen places great responsibility upon the use of photography.

The blue-print process deals with the chemistry of compounds of iron, and involves no silver. It is an old process, dependent upon the chemical facts discovered by the British astronomer Herschel in 1842.

The fundamental chemical fact upon which photoengraving is based is that light causes a mixture of glue and potassium dichromate to become insoluble in water. By washing a metal plate that was coated with such a mixture after it has been exposed under a negative and then etching it, we acquire a metal surface with raised and lowered portions from which a picture may be printed in a printing press in the same way as by use of type. Thus photographic processes tie in with the printing industry.

MOSCOW BOTANIC GARDENS REORGANIZED

At the Moscow Botanic Gardens, conducted under the auspices of the Academy of Sciences of the USSR, botanical research and education are carried on side by side with practical application. Reorganization and expansion are under the direction of Academician Boris Keller. At present the gardens comprise about 250 acres, but when the present program is completed their total area will be 750 acres.

The natural laws governing plant life are illustrated by six distinct sections: plant evolution, experimental ecology, cultivated plants, dendrology, horticulture and floriculture. Russian botanists are especially interested in North American plants and hope to exchange seeds and cuttings, as well as botanical information, with their colleagues in the United States and Canada.

SCIENCE AND THE MENTAL TEST: A STUDY IN CONTRADICTION

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Like so many gadgets adapted to the ends of mass production, the intelligence test has been converted into a mechanical toy whose lever anybody may crank and so get it to spin round by itself. But today it is understandable that many who concocted tests based upon a convenient interpretation of intelligence have more than a subconscious premonition that the bearings upon which their mechanisms were built are wearing out.

The bearings have worn out inasmuch as they were endowed with magical properties, such as a mental seismograph might possess, an instrument corresponding to a lucid mind having knowledge of and understanding insight into human nature in its healthy and sickly condition. But this accomplishment is impossible for a mechanically conceived analogue able to respond only to mechanical, i.e., imitative performances calling only for a limited variety of intelligence valued for its saleability in a society where the sins of the instructors are everywhere periodically visited upon those they have taught.

In this, instructors should learn to see their responsibility for they exercise a successively greater influence upon the student the longer he is obliged to attend school. Decade by decade, the conditionings of formal education assume a more pervasive importance in determining his future. Accordingly, for better or worse, educators contribute to the course of human history.

Look where we may, we shall be fortunate indeed to find a school which does not work irreparable injury to its pupils due to its over-straining for facts without examining their value to minds for whose service they are intended. Without exception, facts are detrimental where there is not sufficient strength of mind to employ them in conjunction with reason wise enough to be harmless. Therefore, the first concern of teaching should be to deal with the building of mind which fact-givings, alone, cannot possibly do.

A jug with a hole in its base will not keep but only waste water. All attempts to fill it must fail so long as its owner does not familiarize himself with its imperfect condition. This applies so much more to the human mind which is meant to use

knowledge aright though it will also, if neglected, dispense it faultily. And it is only when it is realized how responsible the instructor's faulty procedure and mould of thought is for wrongly applied knowledge that education will begin to proceed with the education of mind itself, of its self-critical faculties, instead of making it solely a catch-all for facts. Otherwise, the facts it contains are as stones in the hand of a gamin. In the absence of mind-strength able to control their full meaning, they become missiles in a vast field of distortion.

Let us now look upon the intelligence test which so exactly parallels currently popular methods of instruction to consider how far away the two have taken us from intelligence; from penetration into facts and how they beneficently answer to human needs. Since science is a chief element of intelligence, we may consider questions from mental tests specifically pertaining to physical and biological science. The conclusions derived therefrom must reflect upon the balance of what is contained in the intelligence test of today and consequently upon curricular materials now taught. It stands to reason that the category of science is by no means a special case; in point of fact, all things are inseverably linked together.

The first item to be considered illustrates the fundamental error of using the related facts of science to prove their contrarities, their blunt contrasts, without taking into account the subtle sequences which link them and so prove their kinship. For we often emphatically stress opposites where there is degree of sameness and not any radical opposite denoting complete or absolute difference.

*The water carried by all rivers is salty: true false**

While sea water obviously contains a greater concentration of mineral matter, "sweet" water, whether carried by river or lake, cannot be said to be entirely without salt or dissolved mineral. How else did the oceans become salt if not by rivers and lakes leaching salt from the land? Therefore, unless the difference in degree of content is given, the consideration of this sheer antithesis fails in being properly instructive to which purpose science aims to be faithful. Not to discount differences, if the facts of science are to remain true to the idea of progress,

* The asterisk indicates that a particular word or phrase, from among the alternatives, is credited as being correct by those who have constructed the original question. As presented here, these questions have been slightly altered in wording. However, the original meaning has in all cases been preserved.

the knowledge of the relations of facts must be given as much qualification as the facts themselves which otherwise become untrue statements.

As the moon is to our earth, so the earth is to:

1. Pluto, 2. the sun, 3. stars, 4. universe, 5. Neptune.*

Since our planet, in constitution and behavior, is quite similar to *Neptune* and *Pluto*, it is related to them no less than to *the sun*. Any of these answers, if given, must therefore be regarded and marked as correct.

It may be offered that the knowledge of another, more logical relation is being tested for and not the broader linkage here upheld. In other words, as the moon and no other heavenly body revolves about the earth, so, it will be argued, the earth revolves about the sun. But this is to abstract a much too-specific apposition which is far from being explicitly indicated by the terms of the given proposition.

To continue, as the earth is related to *the sun*, being virtually identical in physico-chemical constituency, behavior, etc., we may say—since spectroscopic examination proves this to lie within the bounds of reasonable inference—that it is related, in these ways, to *stars* and *universe*. Is this too far-fatched, too much at variance with common sense? But why should we not ignore common or any other hedged-in variety of sense and consider merely the justice of the argument? Common sense, as thus interpreted and applied, is merely illiberal sense which does not permit the pupil to grow in understanding. Instead, it imposes an unnecessary division, an unscientific walling-about of the universe, which can never make him more liberal, not in the usual or palliative connotation of the word, but in the sense of freeing him from fundamental misconceptions.

Wheat is to be preferred to corn because:

1. it is more conveniently sold
2. it takes less time to ripen
*3. it is more nutritious.**

Whether wheat is more nutritious than corn remains problematic for it will depend upon how the two have been treated in readying them for consumption. If the integument of the wheat has been removed and the kernel ground into white flour which is then stored prior to being used in bread manufacture, etc.,

its nutritive superiority relative to corn—if, in the first place it be superior—is thereby annulled.

Now generally speaking, wheat is so pre-processed when made into white flour that it loses most, if not all of its mineral and vitamin content, not to disregard those constituents which add necessary bulk. In all likelihood, this would make corn the correct answer. The question is therefore ambiguous in that it does not give the final state in which the two are consumed. Then it is impossible, for the present, at least, to calculate exactly the nutritive value of foods as eaten because mineral and vitamin losses due to cooking are variable. Hence, food tables can give only incomplete approximations with regard to food upon the table. Also, there is the question of natural variation in food, this the result of climatological changes, the differing characteristics of the soil in which it grows, etc., not to dismiss the difficult problem of availability as regards the varying assimilative capacity of the human organism.

Finally, this test item omits to take into consideration the purpose to which a food, whether adequate or poor from the restricted standpoint of nutrition, will be put. An analogy may serve to clarify this point.

If we take two light bulbs, one stronger in illuminative value than the other, and ask which is the more profitable to man, the answer will depend upon the useful or profitable work accomplished by the light of each. Although the weaker bulb might be a strain to the eyesight, great works have been written and noble discoveries made by means of candlelight. And by the light of the best of illuminating systems, cruel mischiefs have been planned and committed. So, similarly, as the light value will depend upon the deeds done with the aid of either bulb, the nutritive advantage of wheat over corn will also depend upon what they are made into when consumed.

The good of anything consequently involves the user. It can never be artificially restricted to the thing itself, including, as it does, the relation of the user to it which will either enhance or depreciate its value. This applies to science with its discoveries and their formulas whose benefits or injuries to man depend upon the reason and morality with which he avails himself of them. The fact that most of the questions asked in science are considered in isolation from the human entity unmistakeably proves disregard for the broadest application of empiricism upon which depends its practical benefits. But if empirical

technique be thus restricted, if the experimenter care not for the upshot of his discoveries upon others and the instructor deal not with this consideration in his teaching, the beneficences of science are only assumptive. Which is a great pity since its findings and tools are ready to be put to intelligent usage—or the contrary. Whether these turn out helpful or damaging will consistently and largely depend upon the user and his quality of developed intelligence. And it is exactly here where the school should but does not enter.

*The velocity of sound is greater than that of heat: true false**

Whether or not this statement is false will depend upon the method of transference of heat which may be through convection, conduction through molecular impact, or radiation. It is well established that the transference of radiant energy, including light, electrical waves, and radiant heat occurs at the same speed through space, viz., 3×10^8 meters per second, and that the speed at which sound traverses dry air at 0° Centigrade is 331.4 meters per second. However, the velocity of heat conduction through convective currents and by means of conduction will, in most instances, be far slower than the latter figure for sound. Now as the method of heat transportation is not indicated, the question is obviously unanswerable by an unqualified negative or positive.

There is a vast difference in value if a question is put in this dogmatic yet equivocal form, or whether given with the purpose of building it into scientific completeness. Only the latter intention can bring out the pupil's present extent of knowledge and help him to acquire more information than that already at his command. But to require him to answer with a customary but unproductive true or false is a licence on the part of a mind which seems, to all indications, to be amusing itself at the expense of the student. Against this he should be protected as in most instances he has no adequate means of defense.

Algebra always has:

1. equations, 2. symbols, 3. equalities, 4. numbers, 5. problems.*

Since algebra is definable as that sector of mathematics which investigates the relations or properties of numbers by means of their symbols, and since algebraic *symbols* consist of literal and arithematical *numbers*, then the fourth alternative must also be

admissible. Further, as *equations* involving *equalities* of numbers enter directly or indirectly into any algebraic problem (thus, addition, substraction, multiplication, substitution, etc., are in last analysis only special instances of the equation), these two terms will also answer the conditions set by this test item. Lastly, what is wrong if one gives as answer *problems* if it be understood as pertaining to that which presents difficulties to be solved?

The Caucasian race is to the Russians just as the Mongolian race is to:

1. Indians, 2. Mohammedans, 3. Chinese, 4. Zulus*

But the ethnologist informs us that the Indians, that is, the Amerindians, belong to the Mongolian race just as much as do the Chinese. It may be objected that the issue of nationhood enters but this again, as in a previous question, is to abstract a particular relation which is by no means specifically indicated by the terms of this item.

Furthermore, this question tests a knowledge which would seem to have little place in what is professed to be a test of intelligence. The person of maturity does not dwell upon differences though he will always take them into account. Yet questions such as this one typically characterize the introductions that we give in the classroom to the theme of racial tolerance. In our contradictory approach, we begin with deviations of skin color, texture of hair, national groupings, etc., instead of placing the greatest emphasis upon racial identities. The end result is that the pupil has but a vague notion of tolerance, the product of a final eulogy on behalf of beclouded notions of "the brotherhood of man." But as this result was superimposed upon a foundation of differences, soon the effects of the eulogy wear off. There remains but the memory of the facts of superficial variation.

Maple trees may lose their:

1. veins, 2. grain, 3. leaves, 4. blossoms, 5. scales.*

Maple trees, as oaks, poplars, beeches, apples, etc., lose both *blossoms* and *leaves* according to the time of year. For blossoms appear on flowering plants or angiosperms—and here the maple must be included—previous to seed and fruit. The term in question happens to be the generic equivalent for flowers, whether or not they be dioecious, that is, having the male and female flowers on separate plants, and if showy or inconspicuous.

Not only this, but the bark constantly weathers off trees. Thus, it is well known that in the sugar maple, the bark will split off in large, loose *scales*. Then, it is certainly possible for maples to lose their *grain* following death and ensuing decomposition. Similarly, for the loss of *veins*, they will disappear due to the operation of the same cause in the root and stem and, of course, will be lost in the fall and winter when the leaves drop off.

A heavy automobile, while travelling, always has more_____ than a light one. The word that best fits the space is:

1. gasoline, 2. volume, 3. momentum, 4. passengers.*

Since the momentum or "impetus gained by movement" is the product of mass *and* velocity, the information given is incomplete for it takes only the masses of both cars into account, that is, mass as connected with weight. Hence, the question is unanswerable unless we indulge those who construct such test items to the extent of relying upon inference at the expense of explicitly stated and exact scientific knowledge. But such indulgence they are unwilling to grant those being tested; only a procrustean yes or no is acceptable.

Were the earth closer to the sun

1. the stars would vanish from sight
*2. the earth would be warmer**
3. the force of gravity would cease to operate.

Since it happens that the earth is not nearer to the sun than it is—which *is* the scientific fact—to suppose otherwise is to introduce a situation no longer occupying a place in science, the discipline which requires a very cold observer, one who does not unnecessarily change facts.

It comes down to this: we have here a question not of intelligence but of willful imagination since all it implies is a probability and that an illegitimate one. For were the condition set forth here ever to become fact, knowledge of what had occurred would be quite useless and, not only that, but impossible of verification. It would be unverifiable because, in the event that the distance of rapprochement were large, it would involve such drastic physical changes that man would not be there to tell the tale.

Every question, if it is to be informative, should pertain to a

living and not a dead humanity. Otherwise, no illustration is given of a knowledge to be intelligently understood; it is merely to ask trick questions, in this instance, one that is fundamentally irreconcilable with the acknowledged facts of astronomy. While such a question might, on occasion, be resorted to as an aid to explain another and more useful fact, by itself it is much too inferential and far-fetched to stimulate learning.

More congruously put, the question might read: "Does the hand feel warmer when it comes nearer to the fire?" At least, here is something one has experienced or can, and the knowledge of which might be of some slight benefit. But the experience of the former is at this time impossible, being a construct of the imagination without direct or circumloquitive worth.

Moreover, the earth is approximately three million miles nearer to the sun at the time of our northern winter solstice and yet the effect of this is quite to the contrary of making the earth warmer whether or not considered hemispherically. In effect, the average temperature, both of the northern and southern hemispheres, is lower at perihelion than at aphelion. This is because the latter hemisphere, owing to the greater extent of ocean as compared with land, and also the considerable cooling effect of the vast Antarctic ice cap, is cooler, according to the best available scientific estimate, by about seven per cent in intensity of intercepted solar radiation.

The conception that the earth is flat is:

1. improbable, 2. absurd, 3. misleading, 4. unfair 5. mischievous.*

What is *absurd* is *misleading* and what is misleading is so because it is *improbable*—and no more than improbable if we are to avoid a dogmatism which goes as counter to the spirit of scientific progress as to the flexibility of mind needed for education. Unfairness enters in admitting but one of these alternative as correct and what is *unfair* is inevitably of *mischievous* consequence.

There is also this to consider: if it is true that this conception be absurd, then it is equally absurd to honor those great figures of science, known and unknown, who helped disabuse men's minds of this view. If the conception of the flatness of the earth be an absurdity, then what merit accrues to those who devoted their lives to proving its state to be otherwise?

Timothy may be classified as a kind of:

1. rye, 2. bamboo, 3. wheat, 4. hay, 5. oats.*

Timothy or meadow cat's tail grass, being a grass, must also be "a kind of" rye, wheat, or bamboo since these are all classified in the order of *Graminae* which takes in the cereals—*wheat, oats, rye*, etc.—the reeds, *bamboos*, and others.

Beside this, there is some cause for wonder that an item of such restricted scope could appear in a test purportedly touching upon intelligence. For it tests only a technical information which a person will know if he has the incentive to know regardless of his level of intelligence. That is, even the so-called moron will know that timothy is used for hay (though he may not know that it is also a grass) if he has lived upon a farm where timothy is grown and fed to cattle. If he is an avid reader, he will also know, but to have read many books and to have some retention of their contents is no sign of the presence of intelligence. Too often it points to the uncreative side of memory which, while on the way to intelligence, is not intelligence itself, is not wisdom in living.

Which of the following differs most from the others?

1. almond, 2. white potato, 3. peach, 4. rose, 5. pear.*

The rose obviously differs from the given possibilities in that it is a flower, the rest being edible fruits and vegetables. But a flower is simply an unripened fruit for it has all the embryonic parts which will some day mature into the ripe seed-vessel and its contents. Therefore, the rose is like all the others with the possible exception of the potato which happens to be a tuber.

A person can measure the length of a city block_____by pacing:

*1. carefully, 2. cautiously, 3. correctly, 4, approximately.**

By pacing *cautiously* and *carefully*, one can *approximately* find the length of a city block. And since what is approximate is not necessarily inaccurate—thus the phrase, "to *correctly* approximate"—all the given possibilities turn out to be correct.

Pasteur won his fame through:

1. politics, 2. science, 3. economics, 4. warfare.*

But did the French government honor and decorate him as a national hero for his work in science or because his discoveries

contributed in such large measure to the prestige and prosperity of that nation prior to the Franco-Prussian war and after when a huge indemnity had to be paid to Germany? Justly interpreted, this question involves the consideration of the agent responsible for building Pasteur's fame and that agent, there can be no doubt, was inspired by political, economic, and even military motives. Hence, all of the given alternatives must be granted credit.

If the French governments, first of Napoleon the Third and then of Thiers and his successors, had not been instrumental in speeding a prestige which eventually became world-wide, it might have come only at the close of his life or even after his death. Which happened to many of the great of science as Semmelweiss, Mendel, Dalton, Lamarck, Willard Gibbs, and others.

Although it is undeniable that splendid accomplishments were there as the basis of Pasteur's work, had they not been exchangeable into financial values and on a huge scale, his fame might not have taken the momentum it did. And the question *is* of that fame which obviously includes the factors clustered together to make it possible and which are all part of any answer which is to offer tuitive experience. Fame is not what historians want to say about their heroes; it depends upon the circumstantial factors which enter into it and which must be taken into discerning account.

As we are scientific, that is, impartial, we find that the renown of Pasteur was not an immediate but only an intermediate result of his experiments, the intervening consideration being its commodity value. Hence, to bind the answer to *science* as this question does, is not to consider the times and attendent circumstances by which his reputation was rocketted. Not that his fame was not due him—it is understood that it was—but the question involves the rapid increase of it at its beginning and later. Such increase was made possible through a mundane-minded appreciation of his discoveries. So far as these contribute to the saving of human lives, no great value was then or is now set upon that unless the human creature dies off in numbers as enormous as did the sheep and fowl and silkworms of Pasteur's day.

The fig comes from a: 1. stalk, 2. tree, 3. bush, 4. lake.*

Without quibbling over the fact that the fruit of the fig tree,

Ficus, is borne upon a *stalk* or peduncle, we may go on to the more important issue as to whether this question tests what is practical and logical and reasonable for the student to know.

Whether figs grow on trees, bushes, or stalks, or are to be found in lakes may be an information of trifling importance compared to the prime consideration which is that every function of the school should faithfully subserve the aim of nurturing the best of mind-development. All mankind should share this opportunity in common before anything else is taught it. Otherwise, such knowledges as where figs come from give no evidence of a fine mind in whose absence we are mental chameleons of every hue but every wrong sort of adaptation of them.

As one puts the plums into the bushel and not the splintered bushel into the plums, so facts should not be piled into the mentality which has yet to become an integrated mind.

There is no reason to withhold facts from the student but let them not be of so insignificant a nature as to require merely the memorial accumulation of concepts and skills. This can neither evoke concentration nor avoid imitative habits at the hands of which potential flexibility for creative thinking is speedily killed.

If we are desirous of aiding the formation of mind by more than fact presentations, we must pursue the method of inquiry which not only uncovers facts but helps the mind to find them for itself. Otherwise, the facts that are given, though they be proven to their discoverers, remain assumptions to those who have not arrived at them by learning how to reason. But through inquiry, one learns the way to reason and the feeling of interested kinship with what is learned. One then explains further facts by explaining what has been learned to one's self, explains thoroughly and with every assumption examined.

Such explanation, it is clear, has not been given by those who have constructed these questions which comprise so large a part of the intelligence test and which are taken from what is offered as authoritative, scientific learning in the classroom. Since what has here been dealt with is in no way atypical, it becomes evident that what we have here is as little a test of intelligence as it is of dependable knowledge. Neither do such problems teach what is connected, clear, and profoundly real for there is no question in existence which can be intelligently answered with the abruptness these so-called measures of intelligence insist upon. Who then can earn the highest score in these scales but

he whose mind is crammed with antiquarian scholastic lore promiscuously mingled and unidentified, that is, unincorporated into an organic system of thought?

In teaching and testing, there is the need to distinguish between facts, that some are fast-frozen in a mold of unreflective, traditional thinking and so produce shallowness, whereas others are free to grow in the mind of the pupil. Concerning the effect of the former, we shall find, through interested investigation, that they gave rise to untoward results, not only because they lead to atrophy of interest in subject matter for the sake of the learning it has to offer, but because in time the accumulation of these static facts has unhappy repercussions in the subconscious and conscious mental life. These effects go beyond the little disciplinary difficulties of which instructors so often complain while inveighing against parents, previous instructors, the motion picture, radio, comic strip, etc. Because they are the result of failure to clarify problems as they arise without standardizing the methods needed to arrive at their understanding, such repercussions even culminate in crazed conditions of mind and varieties of criminality, including those which while infringing upon the property of others, are yet seen as entirely legal.

This is a serious matter and those, who have had their joke with pupils who are as yet unsuspecting of the license taken with them in the name of intelligence, should allow rectification since their word, due to their position, carries permissive authority. But these experts may not reconcile themselves to seeing the nail hit upon the head just as certain medical contemporaries of Pasteur did not reconcile themselves to knowing more of what they did not know and, not only they, but they in different personalities throughout the centuries.

When something appears to us as perhaps confused and therefore unintelligible, we should try to search out for ourselves its undisguised meaning. To try to brush any question aside as unworthy of attention is an attitude often resorted to out of failure to make it immediately coherent to ourselves. And so, with a despatch worthy of pillory-minded schooling, of institutional unthinking, we renounce the matter altogether while assiduously applying ourselves to turning our unoriginal ideas into saleable rating sheets, intelligence tests, measures of aptitude and subject matter; into fatiguingly imitative experimentation with these; and into their monstrously routine application

to the classroom. Thus we apply ourselves—until revolutionary innovations force the matter upon our attention.

Give a man enough rope and he will hang himself is a wise saying, very unwisely understood but not by the teacher who is none other than the philosopher asking belief in nothing but the provable. As it is natural that subtler truth cannot be proven to the grossly inclined mind, he makes it his business to free himself and then others of all accustomed crudity—including quick dismissal of innovatory ideas—which is not "tough-minded" but merely impervious to the misery resulting from mental and moral incompetency.

This saying, to be of instructive value, becomes then a warning against too much rope-giving rather than an invitation to give it freely lest man continue to hang himself by thoughts and deeds braided of ignorance.

APPLICATIONS OF EARTHQUAKE SCIENCE

Seismology, the earthquake science, has become the cornerstone of knowledge for a unique new educational enterprise, the Institute of Geophysical Technology, at St. Louis University under the deanship of Dr. James B. Macelwane, S.J.

Knowledge of the nature and behavior of earthquake waves can be used to man's advantage in two ways, one negative, the other positive. Negative use is the planning of buildings, bridges, dams and other engineering structures in such a way that possible earthquakes will do the least possible damage. Positive use is the generation of small artificial earthquakes by means of explosive charges, and the interpretation of their direction and rates of travel to indicate the presence of deeply buried ore deposits, oil pools and other economically important geologic structures. Courses to be given at the Institute cover both these phases of applied seismology.

Other curricula offered cover training in geological engineering, professional meteorology, radio communications engineering, applied electronics, and general engineering.

SPONGES OF FROZEN CORNSTARCH SUGGESTED FOR INTERNAL SURGICAL DRESSINGS

The use of sponges of frozen cornstarch for internal surgical dressings that can be left in the body when the surgeon sews up the operative wound is suggested by Claude W. Bice, M. M. MacMasters and G. E. Hilbert, of the U. S. Department of Agriculture Northern Regional Research Laboratory. The starch sponges could also be used to introduce medicinals such as penicillin and sulfa drugs into the body during operations. The sponges would be slowly dissolved and absorbed in the body and the medicinal substance at the same time would be slowly released, the scientists believe, on the basis of tests of the studies in beef serum. The sponges are highly absorbent and, unlike cotton, they are firm enough to hold absorbed liquid during gentle handling.

THE ELEMENTARY SCHOOL SCIENCE LIBRARY

PAUL E. KAMBLY
University Experimental School, Iowa City, Iowa

Since 1925 Professor Hanor A. Webb of the George Peabody College for Teachers has prepared an annual list of books for the high school science library. This list has been of great value to a large number of high school teachers and through them also of value to many high school students. The list of books included in this article are references for elementary school science that should be of as much value to elementary school teachers and pupils.

In this first list no attempt has been made to examine and evaluate each book. Many of the titles are included solely upon the recommendation of the publisher. If it is at all possible, future lists will contain only books that have been examined and therefore can be annotated. Although 68 publishing houses were asked to submit titles, there are undoubtedly some publishers that were not given the opportunity to contribute to this list of books. It should be clearly understood that the compiler made a sincere attempt to contact every publisher of children's books and that omissions were not intentional.

Since there is such a great diversity of subject matter taught in different elementary schools it seems impossible to make any suggestions concerning first choices. That decision must be made by each individual teacher on the basis of local needs.

The subject matter divisions under which the books are listed are for convenience only. There may be some errors in the location of a few titles. However, in cases of extreme uncertainty publishers were asked for a further statement concerning the contents of the book before it was placed in the division where it now appears. The grade levels listed are the lowest recommended by the publishers. The prices are of course subject to change. Some companies provided list prices and others gave net price.

REFERENCE BOOKS FOR ELEMENTARY SCHOOL SCIENCE

Ancient Animals

	Gr.	Price
A Parade of Ancient Animals. By H. O. Whitnall. 136 pp. '36. Crowell*	1	$2.00
Ancient Animals. By W. W. Robinson. 96 pp. '34. Macmillan.	5	2.50

* Publishers and their addresses are listed at the end of this section.

	Gr.	Price
Animals of Yesterday. By Bertha Parker. 36 pp. '41. Row	5	.32
How Father Time Changes the Animals' Shapes. By Gaylord Johnson. 185 pp. '43. Messner	5	2.00
Something Surprising. By G. Adshead. 80 pp. '39. Oxford	5	1.00

Animals

(See also lists of books on birds and insects)

Animals Through the Year. By M. W. Buck. 96 pp. '41. Rand	1	2.00
Baby Animals on the Farm. By K. E. Agnew and M. Cobb. 159 pp. '33. World Book	1	.84
Do You Know About Fishes? By Janet Smalley. 44 pp. '36. Morrow	1	1.25
Fun at Happy Acres. By R. C. Barlow and Melvin Martinson. 94 pp. '35. Crowell	1	1.00
Let's Go to the Seashore. By H. E. Huntington. 89 pp. '41. Doubleday	1	2.00
Stumpy. By. F. B. Linderman. 148 pp. '33. Cadmus	1	.75
Tim Tadpole and the Great Bullfrog. By Marjorie Flack. 32 pp. '34. Doubleday	1	1.00
Wallie the Walrus. By Kurt Wiese. 26 pp. '30. Cadmus	1	.72
Life of Baby Animals. By Morse. 60 pp. '38. Follett	2	.45
Our Farm Babies. By Hamer and Hamer. 134 pp. '34. McKnight	2	.80
Prairie Dog Town. By Margaret Raymond. 56 pp. '42. Dodd	2	1.50
Ringtail. By Alice Gall. 119 pp. '33. Cadmus	2	.78
Sled Dogs in Snowland. By O'Brien. 64 pp. '37. Follett	2	.45
Twenty Little Fishes. By I. M. Mellen. 53 pp. '43. Messner	2	2.00
Wild Animals At Home. By Morse. 64 pp. '35. Follett	2	.45
Animals Round the Year. By G. O. Blough and Bertha Parker. 36 pp. '43. Row	3	.32
Animal Tracks. By G. F. Mason. 96 pp. '43. Morrow	3	1.50
Bozo, the Woodchuck. By Brown and Butterfield. 116 pp. '33. American Book	3	.52
Creepers and Sliders. By Morse. 64 pp. '33. Follett	3	.45
Frogs. By Pennsylvania Writers' Project. 48 pp. '42. Whitman	3	.50
Fuzzy and His Neighbors. By J. F. Nonidez. 139 pp. '32. Cadmus	3	.72
Lords of the Old West. By Pennsylvania Writers' Project. 48 pp. '42. Whitman	3	.50
Other Farm Babies. By Hamer and Hamer. 136 pp. '34. McKnight	3	.80
Oysters. By Pennsylvania Writers' Project. 48 pp. '41. Whitman	3	.50
The Reptile Book. By De Sola. 58 pp. '41. Whitman	3	.50
Salmon. By Pennsylvania Writers' Project. 48 pp. '40. Whitman	3	.50
Shenshoo. By Kirkland. 64 pp. '39. Follett	3	.45
Some Animals and Their Homes. By M. G. Phillips and J. M. Wright. 151 pp. '36. Heath	3	.64
The Tale of the Bullfrog. By H. B. Kane. 48 pp. '41. Knopf	3	1.50
The Tale of the Whitefoot Mouse. By H. B. Kane. 48 pp. '40. Knopf	3	1.50
Wagtail. By Alice Gall and F. Crew. 131 pp. '32. Cadmus	3	.78
Whisk; The Story of a Chipmunk. By D. M. Stearns. '41. Farrar	3	1.00

	Gr.	Price
The Zoo Book. By De Sola. 58 pp. '41. Whitman	3	.50
Animals of the Seashore. By Bertha Parker. 36 pp. '42. Row	4	.32
Animals We Know. By Bertha Parker. 36 pp. '42. Row	4	.32
The Burgess Seashore Book for Children. by T. W. Burgess. 329 pp. '29. Little	4	3.00
Child's Story of the Animal World. By E. G. Huey. 355 pp. '35. Cadmus	4	.99
Fingerfins. By W. S. Bronson. 52 pp. '30. Macmillan	4	2.00
Flat Tail. By A. Gall and F. Crew. 128 pp. '35. Oxford	4	1.50
Horns and Antlers. By W. S. Bronson. 143 pp. '42. Harcourt	4	2.00
Now for Creatures! By S. Schackelford. 130 pp. '36. Scribner's	4	2.00
Our Magic Growth. By B. O. Woolley. 138 pp. '37. Caxton	4	2.00
Paddlewings, the Penguins of Galapogos. By W. S. Bronson. 106 pp. '31. Macmillan	4	2.50
Polliwiggles Progress. By W. S. Bronson. 122 pp. '32. Macmillan	4	2.00
Reptiles. By Bertha Parker. 36 pp. '42. Row	4	.32
The Seashore Parade. By M. L. Guberlet. 197 pp. '44. Cattell	4	1.75
Spiders. By Bertha Parker. 36 pp. '41. Row	4	.32
Toads and Frogs. By Bertha Parker. 36 pp. '42. Row	4	.32
Weejack and His Neighbors. By C. L. Fenton. 128 pp. '44. Day	4	1.75
Who Goes There. By D. P. Lathrop. 44 pp. '35. Macmillan	4	1.50
Animals in Black and White. By E. F. Daglish. 256 pp. '38. Morrow	5	2.50
The Book of Zoography. By R. L. Ditmars. 62 pp. '34. Cadmus	5	.99
Bushy Tail. By A. C. Gall and Fleming Crew. 150 pp. '41. Oxford	5	2.00
Casco. By G. Adshead. 64 pp. '43. Oxford	5	1.50
Children of a Star. By J. C. Kenly. 242 pp. '32. Appleton	5	2.50
Fishes. By Bertha Parker. 36 pp. '41. Row	5	.32
Mighty Animals. By Mix. 144 pp. '12. American Book	5	.64
More About Animals. By M. W. Bianco. 115 pp. '34. Macmillan	5	2.00
Our Animal Friends and Foes. By W. A. Dupuy. 275 pp. '25. Winston	5	.66
Some Animal Neighbors. By M. G. Phillips and J. M. Wright. 196 pp. '36. Heath	5	.68
Polaris, The Story of an Eskimo Dog. By E. H. Baynes. 137 pp. '23. Macmillan	5	2.00
The Top of the World. By A. C. Gall and Fleming Crew. 128 pp. '39. Oxford	5	1.50
The World of Animals. By Stephenson. 112 pp. '37. Follett	5	.83
Animals in the Sun. By W. W. Robinson. 56 pp. '34. Cadmus	6	.99
Animal Travels. By Bertha Parker. 36 pp. '41. Row	6	.32
The Museum Comes to Life. By Cormack and Alexander. 207 pp. '31. American Book	6	.88
Squirrels and Other Fur-Bearers. By John Burroughs. 149 pp. '28. Houghton	6	1.08

Astronomy

Dream of Stars. By Pennsylvania Writers' Project. 38 pp. '40. Whitman	3	.50
Looking at the Moon. By Pennsylvania Writers' Project. 48 pp. '40. Whitman	3	.50
The Stars for Children. By G. Johnson. 170 pp. '34. Macmillan	3	1.50
Astronomy from a Dipper. By E. C. Clarke. 80 pp. '33. Houghton	4	1.25

	Gr.	Price
Our Starland. By C. C. Wylie. 378 pp. '42. Lyons	4	.72
First Steps in Science; The Sun and Moon, Vol. VI. By H. McKay. 64 pp. '29. Oxford	5	.50
Let's Look at the Stars. By E. B. Frost. 118 pp. '35. Houghton	5	2.00
Little Star Gazers. By J. A. Schwartz. 104 pp. '17. Lippincott	5	1.50
Our Planet, the Earth, Then and Now. By Rifkin. 62 pp. '34. Lothrop	5	1.40
The Sky Above Us. By Bertha Parker. 36 pp. '41. Row	5	.32
The Story of Earth and Sky. By C. W. and H. C. Washburne. 376 pp. '35. Appleton	5	1.48
What's in the Sky. By E. P. Dunham. 48 pp. '41. Oxford	5	1.00
Astronomy for Young Folks. By Isabel Lewis. 337 pp. '21. Dodd	6	2.50
Introducing the Constellations. By R. H. Baker. 224 pp. '37. Viking	6	2.50
When the Stars Come Out. By R. H. Baker. 188 pp. '34. Viking	6	2.50

Birds

The Bird Book. By De Sola. 58 pp. '41. Whitman	3	.50
Bird Stories. By E. M. Patch. 211 pp. '21. Cadmus	3	.81
Pigeons. By Pennsylvania Writers' Project. 48 pp. '42. Whitman	3	.50
The Tale of the Crow. By H. B. Kane. 48 pp. '43. Knopf	3	1.50
Bird Guides: Water Birds, Game Birds and Birds of Prey East of the Rockies. By C. A. Reed. '21. Doubleday	4	1.50
Birds. By Bertha Parker. 36 pp. '41. Row	4	.32
Bird Stories. By E. M. Patch. 215 pp. '21. Little	4	2.00
Cher Ami, the Story of a Carrier Pigeon. By M. B. Cothren. 84 pp. '34. Little	4	1.25
Our Birds and Their Nestlings. By Walker. 208 pp. '38. American Book	4	.92
Our Bird Friends and Foes. By W. A. Dupuy. 275 pp. '25. Winston	5	.66
The Travels of Our Birds. F. M. Chapman 159 pp. '16. Appleton	5	1.25
What Bird is That? By F. M. Chapman. 144 pp. '35. Appleton	5	2.00
Wild Wings. By J. C. Kenly. 275 pp. '32. Appleton	5	2.50
Our Winter Birds. By F. M. Chapman. 180 pp. '18. Appleton.	6	1.20

Cloth and Costume

Story Book of Clothes. By Maud and Miska Petersham. 30 pp. '33. Winston	4	.45
Story Book of Cotton. By Maud and Miska Petersham. 30 pp. '39. Winston	4	.45
Story Book of Rayon. By Maud and Miska Petersham. 30 pp. '39. Winston	4	.45
Story Book of Silk. By Maud and Miska Petersham. 30 pp. '39. Winston	4	.45
Story Book of Wool. By Maud and Miska Petersham. 30 pp. '39. Winston	4	.45
How We Are Clothed. By Chamberlain. 189 pp. '23. Macmillan	5	1.16

Conservation

Would You Like to Have Lived When? By Mary Melrose and P. E. Kambly. 32 pp. '42. Follett	3	.48
Raindrops and Muddy Rivers. By Mary Melrose et al. 32 pp. '42. Follett	4	.48

	Gr.	Price
Paths to Conservation. By J. S. Tippett. 311 pp. '37. Heath....	5	.92
Down Comes the Wilderness. By M. E. Price. 212 pp. '37. Harpers....	5	2.00
Plants and Animals Live Together. By Mary Melrose and P. E. Kambly. 48 pp. '42. Follett....	5	.48
Nature's Bank—The Soil. By Mary Melrose et al. 48 pp. '42. Follett....	6	.48
Earth's Crust		
The Land We Live On. By C. L. and M. A. Fenton. 90 pp. '44. Doubleday....	1	2.50
Book of Stones. By Pennsylvania Writers' Project. 48 pp. '39. Whitman....	3	.50
The Little Black Coal. By E. C. Eliot. 109 pp. '23. Lippincott..	3	1.00
Trip on Many Waters. By Pennsylvania Writers' Project. 48 pp. '40. Whitman....	3	.50
Wind, Water and Air. By Pennsylvania Writers' Project. 48 pp. '41. Whitman....	3	.50
The Mountain Book. By J. Y. Beaty. 256 pp. '44. Beckley...	4	.90
The River Book. By J. Y. Beaty. 256 pp. '42. Beckley....	4	.90
How the World Began. By Heal. 112 pp. '39. Follett....	5	.83
The Story of Earthquakes and Volcanoes. By Gaylord Johnson. 144 pp. '43. Messner....	5	2.00
Stories Read from Rocks. By Bertha Parker. 36 pp. '41. Row..	5	.32
The Adventures of a Grain of Dust. By Hallam Hawksworth. 251 pp. '22. Scribner's....	6	1.32
Along the Hill. By C. L. Fenton. 96 pp. '35. Day....	6	1.25
The Earth a Great Storehouse. By Bertha Parker. 36 pp. '41. Row....	6	.32
Earth's Adventures. By C. L. Fenton. 207 pp. '43. Day....	6	3 00
Our Earth and Its Life. By M. G. Phillips and J. M. Wright. 288 pp. '36. Heath....	6	.76
The Strange Adventures of a Pebble. By Hallam Hawskworth. 296 pp. '21. Scribner's....	6	1.32
Electricity and Magnetism		
Sparks and Little Sparks. By Freeman. 32 pp. '40. Whitman..	1	.75
Lightning and Electricity. By Pennsylvania Writers' Project. 48 pp. '41. Whitman....	3	.50
Magnets. By Bertha Parker. 36 pp. '42. Row....	4	.32
Working with Electricity. By K. Keeler. 111 pp. '29. Macmillan	4	1.00
The Boy's Book of Magnetism. By R. Yates. 144 pp. '41. Harper	5	2.00
A First Electrical Book for Boys. By A. P. Morgan. 209 pp. '35. Scribner's....	5	2.50
Things a Boy Can Do with Electricity. By A. P. Morgan. 243 pp. '38. Scribner's....	6	2.00
Foods of Man		
Aunt Martha's Corner Cupboard. By Kirby. 128 pp. '28. Whitman....	3	1.25
Story Book of Corn. By Maud and Miska Petersham. 30 pp. '36. Winston....	4	.45
Story Book of Food. By Maud and Miska Petersham. 30 pp. '33. Winston....	4	.45

	Gr.	Price
Story Book of Rice. By Maud and Miska Petersham. 30 pp. '36. Winston	4	.45
Story Book of Sugar. By Maud and Miska Petersham. 30 pp. '36. Winston	4	.45
Story Book of Wheat. By Maud and Miska Petersham. 30 pp. '36. Winston	4	.45

Garden

Happy Days in the Garden. By E. H. Hay. 128 pp. '44. Beckley	2	.80
The Garden and Its Friends. By Bertha Parker. 36 pp. '41. Row	4	.32
Garden Indoors. By Bertha Parker. 36 pp. '44. Row	4	.32
Garden Creatures. By E. King and Pessels. 64 pp. '39. Harper	5	1.25
Peter and Penny Plant a Garden. By Gertrude and France Dubois. 210 pp. '36. Lippincott	6	1.25

General Nature Study

John and Jean. By Pickard and Simpson. 95 pp. '32. American Book	1	.60
Let's Go Outdoors. by H. E. Huntington. 89 pp. '39. Doubleday	1	2.00
Along Our Coast. By Margaret Miller. 60 pp. '42. Dodd	2	1.50
Dicky and Peggy in the Orchard. By M. S. Young. 127 pp. '36. American Book	2	.72
An Aquarium. By G. O. Blough and Bertha Parker. 36 pp. '43. Row	3	.32
First Lessons in Nature Study. By E. M. Patch. 291 pp. '32. Macmillan	3	1.32
Holiday Hill. By E. M. Patch. 135 pp. '31. Macmillan	3	1.20
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Harcourt: Harcourt, Brace & Co., 383 Madison Ave., New York 17, N. Y.
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PORTABLE GAS PLANT

Portable gas generating plant, to make hydrogen for barrage balloons and carbon dioxide for fire protection, is mounted on a 16-ton Army trailer for use in combat areas. The unit contains oil heaters, high temperature catalytic conversion chamber in which the gases are formed from water and alcohol, cooling system and high-pressure compressor.

THE MICROCOSM DEMONSTRATION

WILLIAM J. TINKLE
La Verne College, La Verne, California

A microcosm, a sealed glass aquarium containing plants and animals, is a demonstration that creates a deep impression in a class room or laboratory. It is in place for classes in botany and zoology as well as in classes designated biology. While its inhabitants get along just in the same way as those of any balanced aquarium, this demonstration proves their interdependence by being sealed away from outside help. It is indeed a little world as the name microcosm indicates, or to speak more truly, a model of the adaptations of the world.

For this demonstration any transparent water bottle or carboy of three gallon or larger capacity may be used. If the mouth is large it facilitates the planting of water plants with sticks; but in a small-mouthed bottle the plants can be anchored by tieing each one to a pebble, then placing the sand upon them. Any water plant that gives off oxygen freely may be used, such as Elodea (anacharis) or Valisneria (eel grass).

The sand should be washed, not to make it more wholesome, but so that the water will remain transparent. Agitate the sand in a container under a water faucet and let the faucet run until the water over the sand becomes clear. This should be repeated four or five times.

Water from some clear stream or pond is best, although water from our city system is good. If in doubt, put the water into a balanced aquarium with plenty of plants for a month, then if successful, use it in the microcosm. Water from deep wells or treated with chlorine usually is not safe. The microcosm should be a little more than half full of water.

As for fishes, little ones from your own locality probably are best. Goldfishes can live on a large proportion of plant food, which is an advantage, but are likely to have diseases or parasites since they come from large hatcheries where such pests are hard to control. Several small fishes are preferable to one large one for two reasons: Animals thrive with others of their kind, and if one dies the loss is not felt so much. Three fishes one and one-half inches long are enough for three gallons of water. Fishes should be handled with wet hands, and should be kept a week before placing into the microcosm to insure that they were not injured in catching.

Avoid crayfishes, even little ones, for they grow up and pinch off your plants. Snails are desirable to eat any animal which dies, and they will provide young snails for the fishes to eat. Entomostraca also are desirable fish food, as for example Cyclops, Cypris and Daphnia. A good way to secure them is to dip water from a small stream and pour it through a fine net, doing this repeatedly. Or they may be ordered from a supply house.

After the microcosm is set up, stoppered and sealed with wax, it should be placed where it will get a fair amount of light. Intense light will cause too many algae to grow; which are a sign of a thrifty aquarium, but they make the water green and keep one from seeing inside. We make a jacket of large blotters to enclose the microcosm part of the time. A good way to study this demonstration is to have the student make a full-page diagram or simplified drawing, showing one plant, one fish, and one snail, indicating by arrows what each takes in and gives off.

Biology, the science of life, can not be learned entirely from dead things. The advice of that incomparable teacher, Louis Agassiz, "Study nature, not books," still applies. If you desire the reputation of a wide-awake instructor, set up demonstrations of living things.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1868. Mrs. Walter R. Warne, Marshall, Mo.

1873, 5. Brother Felix John, Philadelphia, Pa.

1875. Joseph Lerner, New York City.

1879. *Proposed by Pearl Yerkes, Fayette, N. Y.*

Solve the system

$$x^2+3x+y=73-2xy$$
$$y^2+3y+x=44$$

Solution by Joseph Lerner, New York, N. Y.

(1) $$x^2+3x+y=73-2xy$$

(2) $$y^2+3y+x=44$$

adding equations (1) and (2),

$$x^2+2xy+y^2=117-4y-4x$$
$$(x+y)^2=117-4(y+x)$$

letting $x+y=z$

$$z^2+4z-117=0$$
$$(z-9)(z+13)=0$$
$$z=9,\quad -13$$

or $x+y=9,\ -13$ from which $x=9-y,\ -13-y$ for $x=9-y$, substituting in equation (2),

$$y^2+3y+9-y=44$$
$$y^2+2y-35=0$$
$$(y+7)(y-5)=0$$
$$y=-7,\ 5$$
$$x=9-y=16,\ 4$$

when $x=-13-y$, equation (2) becomes

$$y^2+2y-57=0$$

solving this, $y=-1\pm\sqrt{58}$, which yields values for x of $-12-\sqrt{85}$ and $-12+\sqrt{58}$. Complete solution (16, −7), (4, 5)$(-12\pm\sqrt{58},\ -1\mp\sqrt{58})$.

Solutions were also offered by Ralph Mansfield, Chicago; J. S. Miller, New Orleans, La.; Dorothy C. Hand, Clark's Summit, Pa.; Sigmund Chamel, New York City; B. Felix John, Philadelphia, Pa.; Morris I. Chernofsky, New York City; Walter L. Warne, Marshall, Mo.; Josiah Yerkes, Bearytown, N. Y.; Eliza Yoder, Fresbies Ferry, N. Y.; M. Kirk, West Chester, Pa.; Hugo Brandt, Chicago; W. M. Kilbourn, Toronto, Canada; and the proposer.

1880. *Proposed by William Cox, Willard, N. Y.*

Solve for x:

$$(a-x)^4+(x-b)^4=(a-b)^4.$$

Solution by Ralph Mansfield, Chicago

$$(a-x)^4+(x-b)^4=(a-b)^4.$$

Obviously, $x=a,\ b$ are solutions of this equation. Hence, by synthetic

division, we reduce the above fourth degree equation to

$$x^2-(a+b)x+(2a^2-3ab+2b^2)=0,$$

for which we obtain solutions

$$x=\frac{(a+b)\pm(a-b)i\sqrt{7}}{2}.$$

Solutions were also offered by M. Kirk, West Chester, Pa.; Milton Schiffenbauer, New York City; Joseph Lerner, New York City; Walter R. Warne, Marshall, Mo.; B. Felix John, Philadelphia, Pa.; Claribel Yerkes, Brooklyn, N. Y.; Morris I. Chernofsky, New York City; Hugo Brandt, Chicago.

1881. *Proposed by Howard D. Grossman, New York City.*

Solve

$$x^2-y=y^2-z=z^2-x=2.$$

Solution by Hugo Brandt, Chicago

The data are equivalent to

$$x^2-y=2 \tag{1}$$

$$y^2-z=2 \tag{2}$$

$$z^2-x=2 \tag{3}$$

from (1):

$$y=x^2-2$$

$$\therefore \quad y^2=x^4-4x^2+4$$

from (2)

$$z=y^2-2=x^4-4x^2+2$$

$$\therefore \quad z^2=x^8-8x^6+20x^4-16x^2+4$$

this into (3):

$$x^8-8x^6+20x^4-16x^2-x+2=0. \tag{4}$$

A partial solution can be gotten from the consideration that the cyclical form of (1), (2), (3), suggest $x=y=z$.

$$\therefore \quad x^2-x=2 \quad \text{and} \quad x=2$$

$$x=-1.$$

Then

$$(x-2)(x+1)=0=(x^2-x-2). \tag{5}$$

Dividing (4) by (5) leaves

$$y=x^6+x^5-5x^4-3x^3+7x^2+x-1=0. \tag{6}$$

This may be factored

$$y=y_1y_{11}=(x^3+x^2-2x-1)(x^3-3x+1)=0$$

$$\therefore \quad y_1=x^3+x^2-2x-1=0 \tag{7}$$

$$y_{11}=x^3-3x+1=0. \tag{8}$$

Both (7) and (8) lead to 3 sets of solutions each as follows:
$y_1=0$ yields

Set 1	2	3	
x_1	y_2	z_3	$=-1.8020$
z_1	x_2	y_3	$=-\ .4445$
y_1	z_2	x_3	$=\ 1.2472$

$y_{11}=0$ yields

Set 4	5	6	
x_4	y_5	z_6	$=-1.8794$
z_4	x_5	y_6	$=\ .3473$
y_4	z_5	x_6	$=\ 1.5321$

These last 3 sets have the property that their sum $=0$, since in y_{11} the term with x^2 is missing, that is $x_4+x_5+x_6=0$.

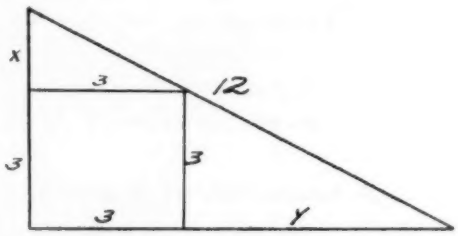
The six solutions above with $x=2, -1$ constitute the complete solution.

Partial solutions were offered by M. Kirk, West Chester, Pa.; and Joseph Lerner, New York City.

1882. *Proposed by Alan Wayne, Flushing, N. Y.*

A square whose side is 3 is inscribed in a right triangle whose hypotenuse is 12 so that the right angle of the triangle is an angle of the square. Find the legs of the triangle.

Solution by B. Felix John, Philadelphia, Pa.



$$(x+3)^2+(y+3)^2=144 \quad \text{or} \quad x^2+y^2+6(x+y)-126=0 \tag{1}$$

$$\frac{x}{3}=\frac{3}{y} \quad \text{or} \quad xy=9 \quad \text{or} \quad 2xy-18=0. \tag{2}$$

Adding (1) and (2):

$$(x+y)^2+6(x+y)-144=0$$

$$(x+y)=-3\pm 3\sqrt{17}=3(-1\pm\sqrt{\ }$$

Using the positive value $(x+y)=3(\sqrt{17}-1)$,

$$y=3(\sqrt{17}-1)-x.$$

Substituting in $xy=9$:

$$x^2-3x(\sqrt{17}-1)+9=0$$

$$x=\tfrac{3}{2}(\sqrt{17}-1\pm\sqrt{14-2\sqrt{17}})$$

$$y=\tfrac{3}{2}(\sqrt{17}-1\pm\sqrt{14-2\sqrt{17}})$$

$$(x+3)=\tfrac{3}{2}(\sqrt{17}+1\pm\sqrt{14-2\sqrt{17}}) \quad \text{or} \quad 11.28;\ 4.0865$$
$$(y+3)=\tfrac{3}{2}(\sqrt{17}+1\pm\sqrt{14-2\sqrt{17}}).$$

Solutions were also offered by Joseph Lerner, New York City; M. Kirk, West Chester, Pa.; W. R. Smith, Suttons Bay, Mich.; Milton Schiffenbauer, New York City; Hugo Brandt, Chicago.

1883. *Proposed by Aaron Buchman, Buffalo, N. Y.*

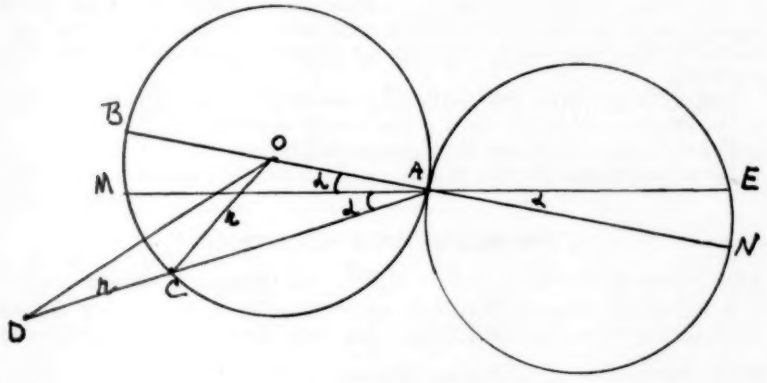
In circle O with fixed diameter AB and variable chord AC, extend AC through C to D, so that $CD=OA$. Draw OD. Bisect angle CAB and extend the bisector back through A to E, so that $AE=OD$. Find the locus of E.

Solution by Hugo Brandt, Chicago

Using the notation of the figure, $AC=2r\cos 2\alpha$, from right triangle ABC. $AD=r(2\cos 2\alpha+1)$. By law of cosines $\overline{DO}^2=4r^2\cos^2\alpha$, after some reductions. Hence $DO=2r\cos\alpha$.

From right triangle BAM, $AM=2r\cos\alpha$. Since $AE=DO$, we have $AE=AM$. Since EAM is a straight line and since M describes the given circle, E also describes a circle of radius r, tangent to the given circle in A.

Solutions were also offered by M. Kirk, West Chester, Pa.; and Harold Lehrer, New York City.



1884. *Proposed by Morris I. Chernofsky, New York City.*

If $a^2=bc$, prove that $a^5+b^5+c^5$ is divisible by $a+b+c$. (More generally, if $a^2=bc$, then $a^{2n+1}+b^{2n+1}+c^{2n+1}$ is divisible by $a+b+c$.)

Solution by Emory P. Starke, Rutgers University

The identities,

$$bc+b^2+c^2=(\sqrt{bc}+b+c)(-\sqrt{bc}+b+c),$$
$$a^3+b^3+c^3=(a+b+c)(a^2+b^2+c^2-ab-bc-ca)+3abc,$$

show that the suggested generalization is not true. However the statement is correct if the exponent $2n+1$ is replaced by $3n\pm1$. The following further generalization is no more difficult to prove: If a_j, $j=1, 2, \cdots, s$, are the terms of a geometric progression, and if k and s are relatively prime, then $\sum a_j^k$ is divisible by $\sum a_j$.

Proof. Put $a_j=a_1x^{j-1}$. Then

$$\sum a_j = a_1 f(x), \qquad \sum a_j{}^k = a_1{}^k g(x),$$

where

$$f(x) = 1 + x + x^2 + \cdots + x^{s-1} = (1-x^s)/(1-x),$$
$$g(x) = 1 + x^k + x^{2k} + \cdots + x^{(s-1)k} = (1-x^{sk})/(1-x^k).$$

To show that $g(x)$ is divisible by $f(x)$, consider $e = \cos(2\pi/s) + i \cdot \sin(2\pi/s)$, whence $e^{sk} = 1$, $c = 1, 2, \cdots, s-1$; but $e^c \neq 1$, $e^k \neq 1$ since ck is not divisible by s. Then $g(e^c) = 0$ and $f(e^c) = 0$, so that $g(x)$ and $f(x)$ are both divisible by $(x-e)(x-e^2)\cdots(x-e^{c-1})$. But this product, being of degree $s-1$, is identically $f(x)$. Hence $g(x)/f(x)$ is a polynomial in x of degree $(s-1)(k-1)$.

Finally, since $a_1{}^{k-1}x^{(s-1)(k-1)} = a_s{}^{k-1}$ is rational integral, then, even though x may be fractional,

$$\sum a_j{}^k / \sum a_j = a_1{}^{k-1} g(x)/f(x)$$

must also be rational integral, as required.

Solutions were also offered by Hugo Brandt, Chicago; Howard D. Grossman, New York City; Martin Dairs, New York City; Milton Schiffenbauer, New York City; M. Kirk, West Chester, Pa.; B. Felix John, Philadelphia, Pa.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

No names appear for this issue.

PROBLEMS FOR SOLUTION

1897. *Proposed by Julius Sumner Miller, New Orleans, Louisiana*

A balloon of mass M falls with an acceleration a. How much ballast must be thrown out in order that it may have an *upward* acceleration a?

1898. *Proposed by Hugo Brandt, Chicago.*

What was the population of the United States when a man by going from New York to San Francisco, a distance of 3100 miles, would shift the center of population by $1\frac{1}{4}$ inches?

1899. *Proposed by Julius S. Miller, New Orleans, Louisiana.*

A pilot is to fly a square course. The sides of the square are d miles. His velocity in still air is v mph. A wind blows constantly parallel to a side, its velocity being w mph. Find the time to fly the course. Assume flight parallel to the sides, and no time for turns.

1900. *Proposed by Mae Edwards, Syracuse, N. Y.*

If any determinant vanishes show that the minors of any one row will be proportional to the corresponding minors of any other row.

1901. *Proposed by Orlando Kelley, Romulus, N. Y.*

If a is any prime number larger than 19, show that $a^{18} - 1$ is a multiple of 9576.

1902. *Proposed by Rita Dorner, Syracuse, N. Y.*

If α, β, γ are the roots of $x^3+px^2+qx+r=0$, find the value of $\sum\alpha^3\beta^2$.

BOOKS AND PAMPHLETS RECEIVED

ATOMS IN ACTION, by George Russell Harrison, *Professor of Physics and Director of the Research Laboratory of Experimental Physics at the Massachusetts Institute of Technology.* Revised Edition. Cloth. Pages xii+401. 14×21 cm. 1944. Garden City Publishing Company, Inc., Garden City, N. Y.

THE RADIO AMATEUR'S HANDBOOK, THE STANDARD MANUAL OF AMATEUR RADIO COMMUNICATION, by the Headquarters Staff of the American Radio Relay League. Paper. 480+184 pages. 16.5×24 cm. Twenty-first Edition, 1944. Published by the American Radio Relay League, Inc., West Hartford, Conn. Price $1.00.

THE RADIO AMATEUR'S HANDBOOK, A MANUAL FOR RADIO TRAINING COURSES, by the Headquarters Staff of the American Relay League. Paper. 288 pages. 16.5×24 cm. Special Defense Edition, 1942. Published by the American Radio Relay League, Inc., West Hartford, Conn. Price $1.00.

A COURSE IN RADIO FUNDAMENTALS, STUDY ASSIGNMENTS, EXPERIMENTS AND EXAMINATION QUESTIONS BASED ON THE RADIO AMATEUR'S HANDBOOK, By George Grammer, *Technical Editor, Q.S.T.* Paper. 103 pages. 16×24 cm. 1942. Published by the American Radio Relay League, Inc., West Hartford, Conn. Price 50 cents.

THE A.R.R.L. ANTENNA BOOK. Paper. 144 pages. 16×24 cm. 1944. Published by the American Radio Relay League, Inc., West Hartford, Conn. Price 50 cents.

THE RADIO AMATEUR'S LICENSE MANUAL. Paper. 32 pages. 16.5×24 cm. 1944. Published by the American Radio Relay League, Inc., West Hartford, Conn. Price 25 cents.

LEARNING THE RADIOTELEGRAPH CODE, by John Huntoon, *Acting Communications Manager, The American Radio Relay League.* Paper. 34 pages. 16.5×24 cm. 1942. Published by the American Radio Relay League, Inc., West Hartford, Conn. Price 25 cents.

TWO HUNDRED METERS AND DOWN, THE STORY OF AMATEUR RADIO, by Clinton B. DeSoto, *Assistant Secretary, American Radio Relay League.* Paper. 184 pages. 16×24 cm. 1936. Published by the Radio Relay League, Inc., West Hartford, Conn. Price $1.00.

SCIENCE IN CHILDHOOD EDUCATION, by Gerald S. Craig, *Professor of Natural Sciences, Teachers College, Columbia University.* Paper. Pages vii+86. 15×23 cm. 1944. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price 60 cents.

EDUCATORS GUIDE TO FEEE FILMS, Compiled and Edited by Mary Foley Horkheimer and John W. Diffor, M.A., *University of Michigan and Visual Education Director, Randolph High School, Randolph, Wisconsin;* Educational Consultant, John Guy Fowlkes, Ph.D., *Professor of Education and Director of Summer Session, University of Wisconsin.* Fourth Edition. Paper. Pages ix+192. 20×27.5 cm. 1944. Educators Progress Service, Randolph, Wis.

BOOK REVIEWS

THE SCIENCE OF NUTRITION, by Henry C. Sherman, *Mitchell Professor of Chemistry, Columbia University* (on leave—*Chief, Bureau of Human Nutrition and Home Economics, Department of Agriculture*). Cloth. Pages xii+253, tables. 14×20.5 cm. 1943. Columbia University Press, Morningside Heights, New York. Price $2.75.

This book is a "must" for the scientist interested in nutrition problems as well as the intelligent layman looking to improving the health of himself and his family. The more than forty years of research spent on these problems have equipped the author for writing such a book as well as for holding important posts as a nutrition expert. The author's name is identified with the "Sherman unit" used in measuring vitamins. The book is in no sense elementary, nor is it so burdened with references to the writings of others in the field that the lay reader would find it uninteresting. It is authoritative and sound with just enough detail of the experimental basis of nutrition to justify the conclusions reached. It is the author's sincere belief that if man will but utilize the knowledge gained by science to more fully nurture his body, the individual, family and national health will be advanced to a state heretofore undreamed of.

The first part of the book gives short reviews of modern ideas of food and nutrition. The history of the discovery and the broadening of our understanding of each of the principal vitamins through experimental feeding is discussed. The last part of the book goes into a discussion of how we may best utilize the knowledge gained to further national health through educational programs, governmental action and economic measures. While Professor Sherman is enthusiastic about formulating a national nutrition policy, he does not seem to be as ambitious as Mr. Henry A. Wallace, whom he quotes in part as saying to a National Nutrition Conference. "We want to *make sure* that our millions are so fed that their teeth are good, their digestive systems healthy," etc. He rather stresses individual responsibility for proper nutrition, with governmental agencies for the most part carrying on further experimentation and sponsoring the educational program. Perhaps there is no more sure way to advance man's physical nurture than by first nurturing his mental side by allowing him to believe he has decided for himself to eat better.

The book contains tables showing amounts of the principal vitamins found in various foods, energy values of foods, calcium content, et cetera. There is a selected bibliography at the end with but very few references through the textual material. A most usable index is added at the end.

HOWARD F. WRIGHT

LABORATORY EXPLORATIONS IN GENERAL ZOOLOGY, by Karl A. Stiles, M.S., Ph.D., *Bert H. Bailey Professor of Biology and Chairman of the Division of Natural Sciences, Coe College.* Paper. Wire-O bound. Pages x+305. 20.5×27.5 cm. 1943. The Macmillan Company, 60 Fifth Ave., New York, N. Y.

Theoretically, the biological laboratory is the place where the students experience for themselves the mysteries of living things. Too often it becomes chiefly a place where embalmed specimens are studied and dissected according to very definite and limited prescribed procedures. In this guide Dr. Stiles has tried to depart as much from this time-worn procedure as is possible in the confines of the laboratory. Whenever possible he gives directions for carrying on explorations on physiological reactions and ecological factors in the animal's environment. A portion of the book is given

to the study of mitosis, maturation, and embryology besides a section giving instructions for carrying out experiments on animal inheritance.

The opening sections of the book discuss the scientific method, its value and how to practice it. Nor does Dr. Stiles dismiss the scientific method with this discussion, for at the end of each section there is a list of questions and problems for further investigation by the student. These problems are often so numerous that it is suggested that the instructor pick only those which best suit individual conditions and the available time.

Since many students feel handicapped at the beginning of the course by a lack of artistic ability, the author includes almost 40 pages of outline drawings of animals, systems, and organs at the end of the book. These are perforated for removal, and punched for placing in the student's own notebook. While many of these are fairly complete drawings in themselves, leaving the student mainly the task of proper labeling, he is encouraged to add any other structures which he found in his specimen which are not included.

The order in which the animals are taken up proceeds from the simple to the complex, and Dr. Stiles lists a number of reasons why he believes this is pedagogically sound; yet he admits that teachers who pursue other plans appear to arrive at the same goal. Hence, he has tried to adapt the manual to either method of approach. While he gives approximately 100 pages to a rather complete discussion of each of the phyla included under the invertebrates, and about the same number to the chordates, almost 75 of the latter are given to a very complete study of the frog. The only other chordate about which he gives complete instruction is Amphious. However, he suggests that the student pursue his study on a fetal pig without specific instructions, on the assumption that now that he has learned the proper techniques and something of the scientific method, he is equipped for proceeding on his own. If the psychological approach has been used and the student has not had almost a year of such practice, it would seem the author's assertion that the manual is adaptable to either method of approach breaks down here.

On the whole, however, the manual seems very usable and an answer to the question of how best to motivate the average beginner in college zoology to apply the scientific method. A bibliography of two hundred reference books is given at the end, separated into the various sub-sciences of zoology.

HOWARD F. WRIGHT

AN INTRODUCTION TO NAVIGATION AND NAUTICAL ASTRONOMY, By William George Shute, William Wright Shirk, George Forbes Porter, and Courtenay Hemenway, *Instructors in Mathematics and Navigation, The Choate School.* Cloth. Pages xiv+457. 14×21 cm. 1944. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

This book was written for the boys who are preparing for service in the Coast Guard, Merchant Marine, or United States Navy. It will be of considerable value to those preparing for the air forces but it is not especially desighed for their use. It is complete in its discussions, requiring no supplementary books, charts or almanacs. Each new term is explained and its use illustrated and often applied in numerical problems. In this manner the student easily learns the many abbreviations used. Problem material is used extensively throughout the book but it involves nothing but the high school mathematics, including elementary trigonometry and extensive use of log tables.

The text is divided into two parts of about 160 pages each. Part I treats the topics of geo-navigation and Part II those of celo-navigation. The chief

instruments used by the navigator, such as the compass, chronometer and sextant, are thoroughly discussed and their uses illustrated by observations and problems. A valuable series of appendixes, with an explanation of logarithms and trigonometric functions and processes including the tables and excerpts from *The American Nautical Almanac*, make up a section of about 125 pages. It is a complete course for the beginners but will require intense thinking and careful study by all high school students. Excellent work in the regular high school mathematics and physics taken as preparation for the course in navigation will be a great advantage to both students and teachers.

G. W. W.

ELECTRICAL ESSENTIALS OF RADIO, by Morris Slurzberg, B.S., M.A., and William Osterheld, B.S., M.A., *Instructors of Electricity and Radio in the Wm. L. Dickinson High School and in the Evening Technical and Industrial High School, Jersey City, New Jersey*. Cloth. Pages xi+529. 13×21 cm. 1944. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $3.00.

This is an excellent preparation for the study of all phases of radio engineering. Many books on radio have appeared in the past three years, some of them giving the impression that the entire field, both theory and practice, can be mastered in a few weeks of intensive work. Many students have failed because they did not know the fundamentals and were not given sufficient time and experience to learn them. This book is for high school boys and young men of similar capacity who are willing to put in the time and energy required to do a first class job. The fundamentals of arithmetic and the ability to read with understanding are the previous requirements. A first class course in the electrical theory and its practice in the field of radio is provided. All pictures, diagrams and problems are taken directly from the radio field and are of definite interest to the student of radio. Each chapter is followed by a list of about a half-dozen excellent references, a rather extensive list of questions most of which are definitely answered in the discussion, and a long list of problems applying directly to the theory just explained. It covers thoroughly and intelligently the electricity for all beginning students who want to learn radio.

G. W. W.

FOOLS AND FOOLISHNESS, by Harry C. McKown, *Editor of School Activities*. Cloth. Pages vii+263. 13×19 cm. 1943. School Activities, C. R. Van Nice, Managing Editor, 1515 Lane Street, Topeka, Kansas.

This book points out the difficulties encountered by new ideas, machines, medicines, foods, etc., in obtaining acceptance or even permission for trial, by government officials and legislative bodies, leading newspapers and periodicals, prominent citizens, doctors, clergymen, teachers, and the public in general. Problems of the home, foods and clothing; the difficulties of communication, industry, and transportation; the applications of science to agriculture; the long struggle of medicine and surgery; the worries, disappointments and criticisms in the field of exploration, the advance of science, and the progress of education; the mistakes, lack of good judgment and disappointments in the realms of literature, music and art; errors in sports and recreations; and the struggle of woman for a place in the world's activities, are the subjects of discussion. In each case the author tells the story in his own language or quotes from some well known book or magazine. Later he mentions many proposed and untried projects in science, some of which the rapid advance due to the intense activity of the World

War has already decided. It is a little book of intense interest, showing how even the greatest of men may err in judgment; how customs, beliefs, religion, prejudice, and business may prevent or delay recognition; how much chance there is yet for improvement, invention, and progress.

G. W. W.

PRINCIPLES OF AIR NAVIGATION, by Bert A. Shields, *Lt. Comdr., U.S.N.R., Formerly Chief Instructor in Charge of Civilian Pilot Training, Polytechnic Institute of Brooklyn.* Cloth. Pages vii+451. 13×20 cm. 1943. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.20.

This is the third of a series of books by the author prepared for high school students planning careers in the field of aviation. Like the other two, *Principles of Flight* and *Principles of Aircraft Engines*, it shows the author's understanding of the limited preparation of the students who will use the book, but also their ability to master a subject in which they are intensely interested. The first two chapters, about one-fifth of the book, discusses maps and map reading. This opens an entirely new field for most high school students. Then follows the discussion of cross-country navigation and dead-reckoning with a description of the chief instruments used and an explanation of the vector problems involved. Chapter 5 is a discussion of the navigation problems and their methods of solution. This is followed by a chapter dealing with radius-of-action problems: (a) flight out and return to the same base, (b) return to an alternate airport, (c) return to a moving carrier. An important chapter on computers and calculators, a chapter on radio navigation, and one on over-water navigation complete the text. Each chapter is followed by an excellent set of questions and problems. The book is well illustrated with pictures, diagrams, maps, and charts.

G. W. W.

RADIO MATERIAL GUIDE, by Francis E. Almstead, Lieut., U.S.N.R., *U. S. Naval Training School, Noroton Heights, Connecticut*, and F. R. L. Tuthill, Comdr., U.S.N.R., *Eastern Sea Frontier Command.* Cloth. Pages xi+242. 12.5×19 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.00.

This book is designed as a textbook for a 16-weeks course for those who plan to train for the armed forces as radio and signal-corps men. It consists of eight short chapters that the boys must know thoroughly. Fifteen pages cover material from the simplest addition to the solution of power factor equations. Five more pages cover tools and soldering. Ten pages, including a diagram of a copper atom composed of 29 protons and an equal number of electrons, treat of the nature and control of electrical energy. By this time the student is supposed to be ready for a study of vacuum tubes. In this rapid manner the entire subject is covered and the facts should be thoroughly learned in the sixteen weeks. Excellent diagrams are given for the explanation of all the most essential theory, and each short chapter includes an extensive list of questions. A valuable appendix completes the book.

G. W. W.

ILLUSTRATED TECHNICAL DICTIONARY, Edited by Maxim Newmark, *Author of a Dictionary of Science and Technology in English, French, German, Spanish.* Cloth. Pages vi+352. 15×23 cm. 1944. The Philosophical Library, New York, N. Y. Price $5.00.

Here is a convenient tool for the beginning student of applied science, industrial arts, and the various mechanical trades. Many people are now working in industries they knew nothing about just a few months ago. A well-selected trade dictionary is necessary or at least very important for their use in becoming acquainted with the terms quite common to the specialist. This book, printed in type sufficiently large to be read without eye-strain, and with definitions selected for the technical worker, will meet most of their needs. Many of the words are followed by an abbreviation of the field from which they are taken. All definitions which are not applicable in industry or applied science are omitted. Certain definitions are given a full quarter page of space; e.g., *duralumin, heterodyne reception, insulin.* A few illustrations are given but some of these have been so reduced in size from the original drawings that they are practically valueless.

G. W. W.

VITALIZED PHYSICS, by Robert H. Carleton, *Head of Department of Science, Summit High School, Summit, New Jersey.* Paper. Pages 378+vi. 12×19 cm. 1943. College Entrance Book Company, 104 Fifth Avenue, New York, N. Y. Price 50 cents.

Vitalized Physics is clearly the product of an experienced high school physics teacher who has discovered that adding extra words, extra pages, and extra illustrations does not always mean a better physics text. There are many less pages in this text than in the average high school text, but the subject of physics is not lacking. The best aspect, in my opinion, is that the author has never lost sight of the fact that physics is a basic, quantitative science and that to understand it requires considerable active effort on the part of the student. The treatment of alternating current is quantitative and more complete than in any high school text I have seen. The graphic, two color scheme in which matters of unusual importance are set off in red is interesting, novel in a way, and it should be effective.

The author has learned that answers to problems are in themselves unimportant. He has included them along with a very excellent selection of vital problems. Perhaps the answers could have been given as well in black. Giving them in red may give some students the idea the answer is important rather than the method of solution and its understanding. A good, concise, but complete treatment of physics as *Vitalized Physics* could well have been bound in cloth, and printed on better paper.

H. H. SIEMERS,
Shortridge High School,
Indianapolis, Indiana

FIRST-YEAR ALGEBRA, by Raleigh Schorling, *Head of the Department of Mathematics in the University High School and Professor of Education in the University of Michigan;* and Rolland R. Smith, *Specialist in Mathematics in the Public Schools in Springfield, Massachusetts;* with the cooperation of John R. Clark, *Teachers College in Columbia University.* Pages xiv+466, 14×20.3 cm. 1943. World Book Company, New York, N. Y. Price $1.56.

In the preface to their First-Year Algebra, the authors have stated the purpose of the text and their conception of the presentation of the subject matter clearly and concisely. According to them the present emergency does not necessitate any change in the philosophy of teaching but a change in the emphasis on various topics, particularly as far as material required by our armed forces is concerned.

Thus we have a text book which puts the emphasis squarely and directly

on algebra with less attempt at correlation between algebra, arithmetic and geometry. The transition from elementary arithmetic to algebra is developed by the introduction of algebra as an "extension of arithmetic" or "generalized arithmetic."

The first three chapters lay this basic foundation in stressing the symbolism of algebra and developing the understanding of letters as numbers in simple examples of the four fundamental processes and the equation. In the second chapter the formula is introduced, only to be used much more extensively in the following one with examples from geometry. Graphing is introduced early in the book as a means of picturing numbers. Those presented are certainly on the intelligence and interest level of the 9th grade pupils and promote the idea of the relation and dependence of numbers. The graphing of equations comes in the second semester's work.

The one big dread of all beginning students; namely the story problems receive careful treatment with the one purpose of enabling the pupil to analyze his problem, see the relation between the numbers and thus form his equation.

The mechanics of the book are excellent. The pages are very easy to read, the illustrations are many and timely, and care has been exercised to provide interest and attraction for the pupil. The usual provision for the varying abilities of the pupils has been made and the problems and exercises are written and arranged with this point in mind. Likewise, at the end of the chapters, a summary and customary types of tests are to be found.

No one, not even an experienced teacher, should ettempt to use this text without familiarizing himself with the "Notes to the Teacher." To accomplish the best results with a specific text, the teacher must constantly bear in mind the aims, purposes and methods of presentation of the authors.

As one would expect from such outstanding mathematicians and teachers, the book is a simple, clear and teachable text based on sound pedagogical principles. Many of the problems used are the result of experimentation in the Springfield High School.

To some teachers there might seem to be a too great dearth of arithmetic and geometric review, as well as a failure on the part of the authors to fulfill their promise to include material pertinent to the needs of the military emergency.

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PLANE GEOMETRY, by A. D. Theissen, formerly instructor in mathematics, *Marquette University High School*, and Louis A. McCoy, *Head Master, Girls High School, Boston, Massachusetts*. Cloth. Pages viii+344. 13.5×19.5 cm. 1943. Loyola University Press, 3441 North Ashland Avenue, Chicago, Illinois. Price $1.40.

Geometry is geometry and twenty-five years teaching of it should teach a logical and psychological method of presenting the same. The authors seem to have accomplished this idea. The text differs from many of the newer texts in that the authors give the proof and reasons for the proof statements. In this and other respects, in my opinion, the book resembles the texts of thirty years ago. There are many helpful summaries. Many of the lists of exercises are preceded by good oral reviews. It is a teachable book.

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MATHEMATICS FOR VICTORY, by Virgil S. Mallory, *Professor of mathematics and instructor in The College High School, State Teachers College, Montclair, New Jersey: Pre-Induction Committee on Mathematics for the Victory Corps; War Department Committee on Civilian Pre-Induction Mathematics (A.S.F.)*. Cloth. Pages vii+430. 13×19 cm. 1943. Benj. H. Sanborn and Company, Chicago, Ill. Price $1.64.

Mathematics for Victory meets the needs of those who are expecting to enter the armed services, nursing, industry or civilian life.

The first half of the book is devoted to the fundamentals of arithmetic, algebra, geometry and trigonometry. The latter half of the book deals with practical problems involved in various occupations—problems which require the use of mathematics studied in the first half of the book.

The book can be used any year in the high school. Explanations are sufficient for use in the first part of high school or as a refresher course for the more advanced students. There are ample tests and review questions throughout the book.

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A MATHEMATICS REFRESHER, by A. Hooper. Pages vii+342. 19.8×14 cm. September 1942. Henry Holt & Company, Inc., New York, N. Y. Price $1.32.

This book has been aptly named "a mathematics refresher." But it not only serves that purpose well, it also serves to coordinate the separate courses of mathematics into a well ordered sequence. It should be a required course for every senior preparing for college.

The book is especially suitable for the person who does not discover his need for mathematics until after leaving school. It contains full and complete explanations, and the order in which the units are presented is so well planned that, with study, any person should be able to attain a certain proficiency in mathematics and gain a clear gasp of the mathematical processes of reasoning.

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ARITHMETIC FOR THE EMERGENCY, a text-workbook. By G. M. Ruch, F. B. Knight and John W. Studebaker. A revision of *Self-Help Mathematics Workbook Two*. Paper; 176 pp.; 20×28 cm.; 1942; 64¢. Scott, Foresman and Company, 623 S. Wabash Ave., Chicago.

The publishers state "The student who goes through this book seriously and conscientiously will acquire the mastery of simple arithmetic so important in every phase of the war effort." The book is planned to enable the student to discover his own individual weaknesses in arithmetic, to re-learn, on his own initiative, the correct way of doing those processes in which he is weak, to give him the necessary practice and to check on and record his improvement. The core of the book is a series of 20 diagnostic tests each composed of 20 examples involving all the fundamentals of arithmetic, each test to be finished in twenty minutes. The administration of the book centers about these tests, the weaknesses they uncover and the means provided for correction. The book is a twin of *Mathematics for the Emergency* in size, makeup and cover design. In the review copy, the authors' last names appear on the cover but nowhere else; the positions held by the authors are not given.

GLENN HEWITT

COMPLEXITY OF MENTAL PROCESSES IN SCIENCE TESTING, by Frederick Thomas Howard, Ph.D. Cloth. Pages v + 54. 15 × 23 cm. 1943. Bureau of Publications, Teachers College Columbia University, New York City. Price $1.75.

This study investigates the nature of the relationship between ability to recall specific information and the ability or abilities to perform more complex mental tasks. A study of item complexity is made, and a rather sound technique for determining objectively a test composed of progressively more complex items is described. These techniques should be useful in future studies exploring further the nature of item complexity, and in the evaluation of differential objectives in other fields of instruction as well as in science. The author concludes that the items of an objective test can be reliably ($R = .92$) placed along a continuum from the more specific to the most complex—from simple memory items to those requiring a considerable degree of association and integration.

The value of such a test as measures of level and power used in connection with the standardized intelligence tests is rather promising.

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CONSUMER EDUCATION, by James E. Mendenhall, *Office of Price Administration, Washington, D. C.* and Henry Harap, *George Peabody College for Teachers.* D. Appleton-Century Company, 1943. New York.

With our educational system being directed toward providing for the needs of the individual so that he may be able to enjoy the fullness of life in a democratic society, training in consumer economics becomes extremely important. General life outside of activities connected with operating a business involves many economic operations and principles which will be either neglected or improperly done unless there is adequate training in the schools in such operations. None of the cardinal principles specifically include this objective. The need and the problem of consumer education is very thoroughly and comprehensively analyzed in this book. The expectation which the names of the authors of the chapters and of the collaborators in some of the chapters naturally arouses is well realized by the written text. The extent of consumer education and its placement in the various school divisions from the elementary school to the college, the extent of its incorporation into the various subjects of the curriculum or its organization into special courses are fully examined. The need of knowing the principles of consumer's economics is also established. That our system of economics as taught in schools gives insufficient place to consumption is very well taken. Consumption is an essential part of economics. Reduced to philosophical terminology, production involves the efficient cause while consumption the final cause. Consumption, however, also is part of the efficient cause. To satisfy this need of consumption, business must not only produce articles fit for consumption and at the price that the consumers can pay and bring the consumer to buy the completed articles, but must also create the very consumers. In establishing a business the entrepreneur should not only set plans for production but also plans for creating consumers. Some of the figures of income given in connection with budgeting are rather out of date. There are some repetitions as one would expect in a book where each chapter is written by a different author. The book should be read by all educators and especially by superintendents, principals, and the officials of colleges, and the faculty of the departments or schools of commerce and education of universities.

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MINIATURE WET STORAGE BATTERIES FOR FLASHLIGHTS

Rechargeable miniature wet storage batteries for flashlights for industrial uses, recently developed and now thoroughly tested, are designed to replace the non-reusable dry cells, particularly where long continued and steady usage of flashlights is necessary. In actual use in a test period of 18 months by the B. F. Goodrich Company in home factories and in other large industrial plants elsewhere, they are proved to have dependability, economy and long life.

The new wet battery requires a special type Mazda lamp, a 600 mil lamp in contrast with the 300 mil lamp used with dry cells. Actual wattage consumed with the wet battery is 50% more than with the dry type but a distinctly brigher light is given. The wet battery will outlast 400 dry cells, the Goodrich Company claims.

NEXT PERIOD OF SUNSPOT MAXIMUM WILL PROBABLY COME EARLY

The next period of sunspot maximum will probably come early, the number of pockmarks on the sun for the present cycle being greatest sometime before May, 1948.

On the average 11.1 years elapse between two successive periods of sunspot maximum. One can expect, with 95 chances out of a hundred of being right, that the interval from the last maximum to the next one will be shorter than usual, Dr. W. Gleissberg of Istanbul University Observatory reports in the *Astrophysical Journal*.

After the last sunspot maximum, which occurred in April, 1937, the number of freckles on the sun decreased very gradually. Because of the slow decline of this cycle, it might easily be supposed that the interval between the last sunspot maximum and the next one would be relatively long. The laws of probability, however, indicate that this interval will be shorter than average, Dr. Gleissberg reports.

NATURAL GAS, UNLIKE MANUFACTURED GAS, FOUND HARMLESS TO POTTED PLANTS AND CUT FLOWERS

Natural gas was found non-injurious to growing plants and cut flowers, in experiments by Prof. Felix G. Gustafson of the University of Michigan. In this it is radically different from manufactured gas, which has long been known to be very harmful to plants growing in homes and greenhouses, as well as to certain kinds of cut flowers.

Prof. Gustafson placed potted plants of tomato, coleus, sunflower, snapdragon, marigold and several other species, as well as cut flowers of tulip, carnation and stock, under bell-jars. In some of the bell-jars from one to two per cent of Texas natural gas, taken directly from the pipe line, was added to the atmosphere. Other jars were left with only ordinary air in them, as controls.

Although the plants were exposed to the natural gas for several weeks, none of them developed detectable injury in the one per cent gas atmosphere, and only two of the cut specimens of plants showed damage in the two per cent concentration.

As a further check, manufactured gas was added briefly to some of the bell-jars containing natural gas. The plants promptly showed signs of gas injury, but recovered when the manufactured gas was taken out and only natural gas remained.